Radiation
Data and Reports

U.S. ENVIRONMENTAL PROTECTION AGENCY

Office of Radiation Programs

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^9	giga	G	jī'ga
10^6	mega	M	mĕg'a
10^3	kilo	k	kĭl'lo
10^2	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mī'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
A	ampere(s)	
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps-2.22×10^{12} dpm
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	3.527×10^{-2} ounces= 2.205×10^{-3} pounds
Hz	hertz	cycle per second
kVp	kilovolt peak	
m	meter(s)	39.4 inches=3.28 feet
m^3	cubic meter(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
mi	mile(s)	
ml	milliliter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g
r/min	revolutions per minute	
s	second	
yr	year	

RADIATION
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RADIATION DATA AND REPORTS

U.S. ENVIRONMENTAL PROTECTION AGENCY
Russell E. Train, Administrator

HF Spectral Activity in the Washington, D.C. Area

Richard A Tell, John C. Nelson, and Norbert N. Hankin [1]

The results of preliminary study on the spectral activity of the high frequency band from 0 to 100 MHz with emphasis on the 2–22 MHz band segment are presented. In the 0–2 MHz band segment, which includes the AM standard broadcast region, the highest mean number of signals recorded in any one hour was approximately 14.3 that occurred at 1800 e.d.t., the minimum mean number of signals observed was 8.2 occurring at 0200 e.d.t., and the maximum integral relative power density occurred at 1800 e.d.t.

In the 2–22 MHz band, the peak band activity and peak integral spectral power density both occur between 1800 and 2400 e.d.t. The maximum integral power density is about 20 dB greater during this time period than at other times.

For the overall band of 0–100 MHz, the highest activity appears to occur from about 0900 to 1800 e.d.t. There is a lull in activity that occurs in the early morning hours (0200 to 0600 e.d.t.). The inactivity of nonbroadcast sources is generally correlated with the overall band activity. Measurements show that signals of nonbroadcast origin are significantly lower in amplitude than signals in the broadcast bands.

Quantitative determination of ambient radio-frequency (RF) and microwave exposure levels is currently a topic of great interest to individuals concerned with the possible health implications of this form of electromagnetic radiation. Attention to the possible deleterious interaction of nonthermal levels of RF with humans continues to grow (*1*). Due to a lack of definitive measurements on background levels, several fundamental problems persist:

(a) without good, basic information about typical environmental levels of RF and microwave energy experienced by the general populace, it is difficult to efficiently design biological effect experiments which practically relate to day-to-day type exposures,

(b) the interpretation of present day biological research is encumbered due to an incomplete picture of the electromagnetic environment in terms of its amplitude, frequency, and time history characteristics, and

(c) with the ever increasing use of sophisti-

cated electronics in critical situations (e.g., the wearing of cardiac pacemakers and the use of various automotive systems such as electronic ignition, braking, and collision avoidance systems) and an apparent increase in their electromagnetic interference (EMI) susceptibilities, it is important to understand the nature of the electromagnetic environment in which these sensitive devices must exist and reliably operate.

(d) When definitive health effect information on the nonthermal area is available, the electromagnetic environment must be well defined to measure the impact of proposed regulatory standards.

The Electromagnetic Radiation Analysis Branch conducts a program of developing information about the electromagnetic background for these purposes. Under current development by this branch is a semiautomated environmental RF measurement system which will be used to collect data on ambient RF levels. When completed this measurement system will be deployed in the field for data collection and analysis. Prior to its deployment, various sampling approaches have been under consideration.

[1] U.S. Environmental Protection Agency, Electromagnetic Radiation Analysis Branch, Office of Radiation Programs, 9100 Brookville Road, Silver Spring, Md. 20910.

This report discusses a preliminary study on spectral activity in the 0–100 MHz region and particularly in the high frequency band segment of 2–22 MHz. The purpose of the study was to develop insight into the time and frequency variations in observed received signal activity. Through such insights, a practical set of sampling criteria can be generated, allowing a more efficient use of the measurement system in collecting field amplitude-frequency data.

The data represented in this report were taken at the Electromagnetic Radiation Analysis Branch's instrumentation facility in Silver Spring, Md., during the period July 31 to August 6, 1973.

Objectives

This study had several specific objectives:

(a) to determine the relative occupancy of the standard AM broadcast band as a function of time of day and to obtain an indication of the relative contribution of all observable signals to the overall spectral intensity in terms of exposure;

(b) to determine some index of the contribution of nonbroadcast signals to the total spectral activity in the 0–100 MHz frequency range; and

(c) to examine the relative occupancy in a segment of the high frequency (HF) band (2–22 MHz) as a function of time of day, directional characteristics of the arriving signals, and frequency.

Measurement equipment

Signals in the HF band are characterized by intermittent occurrence and poor stability; these two characteristics are present because (a) much of the band is used for communication activities which routinely are of an on-off nature, and (b) essentially all of the band is subject to highly variable propagation conditions resulting in significant signal fade. The predominant propagation mode accounting for long distance telecommunications in the HF band is earth-ionospheric reflection which is a function of upper atmosphere ionization density and ionospheric height and thickness. Due to the relatively high dynamic character of HF

signals, an adequate data acquisition technique which possesses a high collection speed should be used for maximum accuracy in determining spectral activity. In lieu of having such a system available, which typically would involve an automated operation of a scanning spectrum analyzer through an interface with a minicomputer storage system, our data reported here must be considered as preliminary and used as only semiquantitative indicators of spectral activity.

The measurement system used is diagrammatically illustrated in figure 1. The principal instrumentation consisted of a spectrum analyzer capable of scanning the frequency range of approximately 0 to 110 MHz or any selected segment of this range, an oscilloscopic camera for producing photographs of the visual spectral display from the analyzer, a tracking generator which is useful for determining the center frequency of the scan made by the spectrum analyzer, and a selection of two different antennas consisting of a rotatable planar, log periodic antenna, and a random length, long wire antenna. The log periodic antenna had a nominal gain of 7–12 dBi (isotropic gain) over its frequency range of 6.2 to 30 MHz with a nominal 3 dB beam width varying from 70
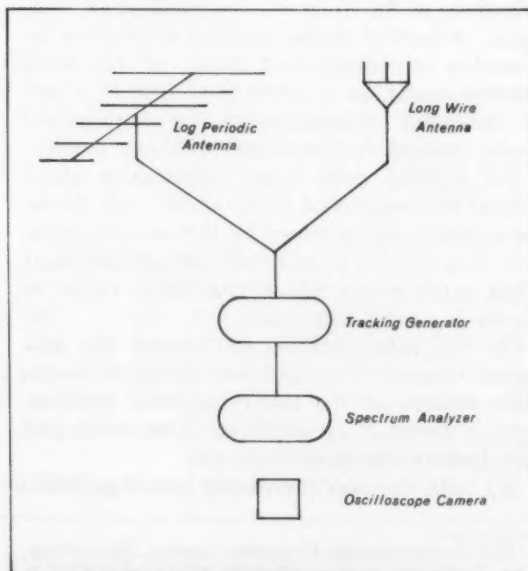

Figure 1. Measurement system diagram

Table 1. Measurement equipment summary

Equipment designation	Model and manufacturer
Spectrum analyzer consisting of:	
Variable persistence display section	Model 141T, Hewlett Packard
110 MHz RF section	Model 8553B, Hewlett Packard
High resolution IF section	Model 8552B, Hewlett Packard
Oscilloscope camera	Model 197A, Hewlett Packard
Tracking generator	Model 8443A, Hewlett Packard
Log periodic antenna	Model LP-1017, Hy-Gain Electronics

to 90 degrees and a front-to-back ratio of 2 dB at 6 MHz to 14 dB at 21 MHz. Table 1 summarizes the specific measurement equipment.

Sampling procedures and data analysis

The method used in data collection consisted of setting up the analyzer for the appropriate frequency range, band width, scan repetition rate, spectral amplitude display range, and connection of the desired antenna at the designated sampling times. A usable spectral display was then generated on the cathode ray tube (CRT) of the analyzer from which a photographic record was made. All photographs and associated control setting information were serialized so that analysis of the data at a later time was orderly.

The measurement scheme outlined in table 2 was used during the data collection for this report. Analyzer band widths were chosen on the basis of being compatible with typical signal band widths found in the various frequency regions investigated. The data obtained through this procedure represent an instanta-

Table 2. Measurement scheme outline

Frequency range (MHz)	Date (1973) (time e.d.t.)	Antenna*	Sample internal (h)	Total measurements	Band width (kHz)
0–100	7/31–8/1 (1200–1200)	L.W.	1	25	
0–100	8/1–8/6 (1400–1200)	L.W.	2	60	
0–2	7/31–8/1 (1200–1100)	L.W.	1	24	3
0–2	8/1–8/6 (1400–1200)	L.W.	2	60	3
2–22	8/2–8/6 (1400–1200)	L.W.	2	48	10
2/22	7/31–8/1 (1200–1200)	L.P.	1	25	10
2/22	8/1–8/2 (1400–1200)	L.P.	2	12	10

* L.W., long wire antenna
  L.P., log periodic antenna

neous record of spectral activity at a specific time and are thus not results of a long, time averaging technique whereby a continuous flow of spectral data was monitored and maintained over the study period of 6 days. However, due to the rather small time increment between measurements, it was felt that a reasonable indication of gross time-of-day variations in activity could be detected and this proved to be the case as is apparent in the results section.

Analysis of the data was performed by examining the relationship between several parameters, specifically:

(a) the mean relative number of signals observed within a given frequency band whose amplitude exceeded a defined threshold value;

(b) the mean relative power of each signal above a defined threshold value in units of dBm where 0 dBm is equal to 1 milliwatt or the mean relative power density in units of dBm/cm^2, e.g. -10 $dBm/cm^2 = 0.1$ mW/cm^2;

(c) the subband frequency within the overall frequency scan;

(d) the direction of the rotatable log periodic antenna; and

(e) the time of day in eastern daylight time (e.d.t.).

In all cases, the measured data were presented as signal amplitude-frequency displays with the amplitude information displayed logarithmically such that signal power could be easily compared between signals on a decibel (dB) basis. This is particularly convenient due to the large dynamic range in amplitude values.

A threshold of 52 dB down from the maximum observed signal amplitude was used for counting the standard AM broadcast spectrum data. This represented a level at which the noise level became significant.

The 0–100 MHz scans were analyzed for an indication of the amount of nonbroadcast signal activity by comparing signal counts in the entire 0–100 MHz scan to the number of signals observed within a fixed subband which was established between the high end of the HF band and the low end of the VHF television broadcast band. Within this frequency subband, the principal signal contribution is due to various communication services, notably part

of the land mobile service and other two-way radio communication activities. Such observations were made in order to assess impact of intermittent signal services upon the fairly stable, daily exposures from the broadcast sources. This particular comparison was made by finding the ratio of signals counted in the subband to those found in the entire 0–100 MHz band and expressing the results as a percentage. In another case, the ratio of maximum observed signal power in the entire band to that in the subband was determined in an effort to find the relative importance of the exposure from this subband.

For the AM standard broadcast band, an analysis of the effect of individual signals on the total spectral power density was determined. This was accomplished by taking a representative spectral display and expressing the accumulative percent of total integrated spectral power density as a function of the accumulative number of signals in order of increasing power.

Spectral activity in the HF band was high and presented a tedious problem of manually extracting data (both signal count and amplitude) from the spectral photographs because of the large number of signals present. In this case, a sliding threshold was utilized for each subband segment of the 2–22 MHz region measured. Signals were tabulated for each subband on the basis of individual signal distinguishability, the difference in amplitude be-

tween the lowest distinguishable signal and the next highest signal complex (possibly a complex of several weak signals escaping frequency resolution by the analyzer), and the threshold selected for that band. Despite the variabilities in the above procedures, overall estimations of integral spectral power displayed within each subband (2 MHz width) are considered accurate to ±30 percent.

Since all data were taken from the standpoint of determining relative activity within various frequency regions, no attempt was made to ascertain in this study, the absolute field intensities from measured signals. Such a determination would require complete characterization of the antenna system used and transmission lines used to connect the antennas with the instrumentation.

Results, 0–20 MHz

Results of spectral measurements in the AM standard broadcast region (0.54–1.6 MHz) are given in figure 2 for the first day of observations wherein measurements were made once per hour. Figure 3 is a plot of similar data collected over a total of 6 days. The principal observations from these two graphs are:

(a) the maximum mean number of signals exceeding the measurement threshold was approximately 14.3 occurring at 1800 e.d.t.;

(b) the minimum mean number of signals
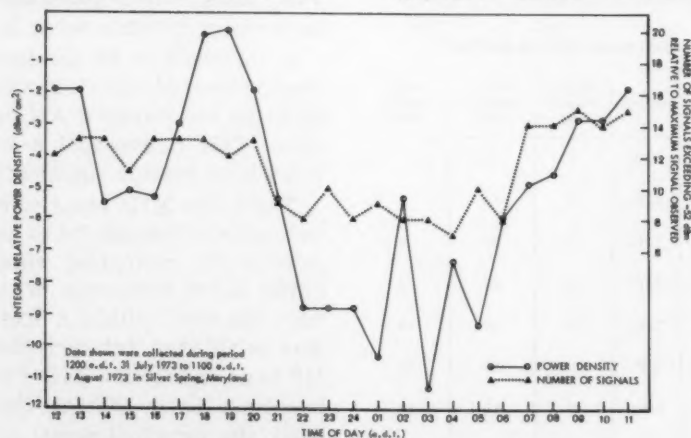
Figure 2. Integrated relative spectral power density in the AM standard broadcast band (1 day)
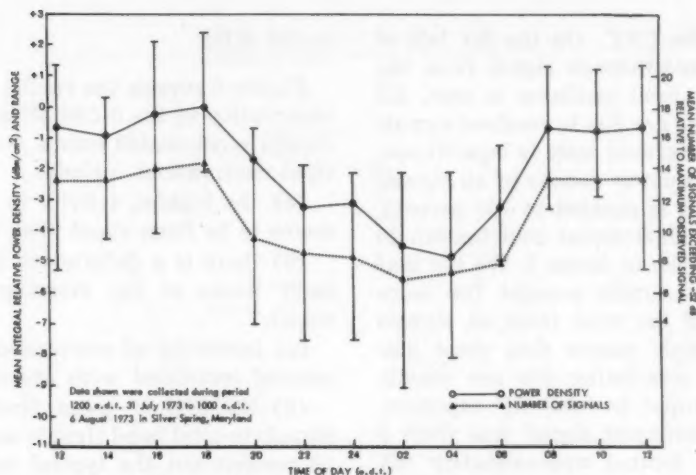
Figure 3. Mean integrated relative spectral power density in the AM standard broadcast band (6 days)

observed was 8.2 at 0200 e.d.t.; and

(c) the integral relative power density tracked the mean number of signals observed with a maximum value occurring also at 1800 e.d.t. while the minimum integral value dropped more than 5 dB from the maximum.

The gradual dropoff in integral power density after 1800 e.d.t. is probably due to deterioration of ground wave propagation at night at our monitoring site. After 2400 e.d.t. several local stations cease operation until approximately 0600 e.d.t. This operational characteristic of the stations is apparent in the dip in figure 3 at 0400 e.d.t.

Figure 4 is an illustrative picture of the spectral display of the 0–2 MHz spectrum from the analyzer. The center frequency for this scan is 1.0 MHz with a frequency dispersion of 200
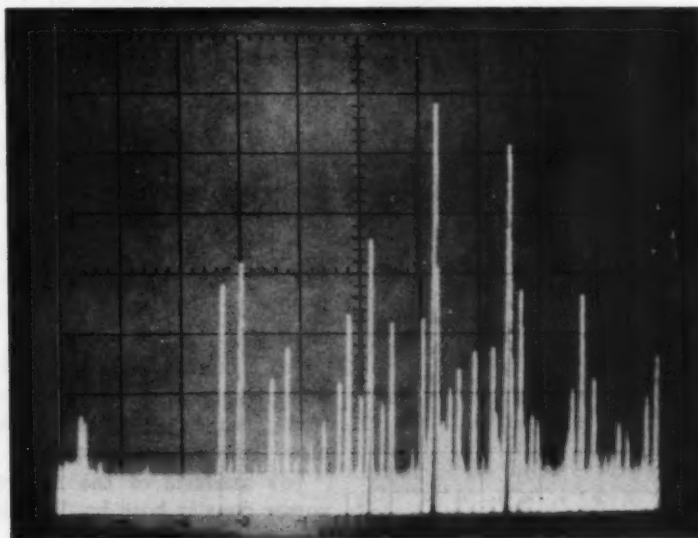
Figure 4. Spectrum analyzer display of 0–2 MHz scan

kHz/division on the CRT. On the far left of the display, the feed-through signal from the spectrum analyzer local oscillator is seen. All other spectral peaks are due to received signals up to 2 MHz. The vertical scale is logarithmic. If the total integral power density of all signals above the threshold is equated to 100 percent, the effect of individual signal contribution to this total may be seen in figure 5. We see that the two strongest signals account for more than 96 percent of the total from all signals detected. This simply means that those stations nearest the monitoring site are usually the predominant input to total RF exposure. In our case, the strongest signal was from a broadcast station located approximately 0.8 km (0.5 miles) away and the second strongest station about 1.6 km (1.0 miles) distant.
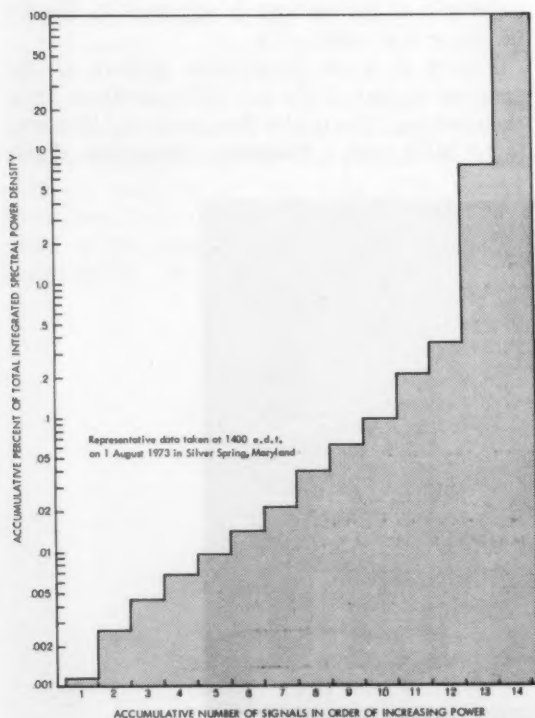
Figure 5. Effect of individual signals on total spectral power density in the AM standard broadcast band

0–100 MHz

Figure 6 reveals the results of the first day's observation of the 0–100 MHz. Figure 7 shows results accumulated over a 6-day period. Principal observations include:

(a) the highest activity in the overall band seems to be from about 0900 to 1700 e.d.t.,

(b) there is a definite lull in activity in the early hours of the morning (0200 to 0600 e.d.t.),

(c) inactivity of nonbroadcast sources is in general correlated with overall band activity,

(d) the highest mean fraction of subband signals to total band signals was approximately 19 percent but the typical value appeared to be more on the order of 10 percent, and

(e) measurement shows that signals of non-broadcast origin are significantly lower in amplitude than signals in the broadcast or HF bands, typically by more than 50 dB.

2–22 MHz

Figures 8–12 are graphical representations of HF spectral data. Some observations on these results are the following:

(a) there is a general correlation between peak band activity and peak integral spectral power density; however, there seems to be a slight shift in time at which both occur. Both functions peak between 1800 and 2400 e.d.t. The maximum integral power density in this time range is on the order of 20 dB greater than at other times. The slight shift in time (peak power density occurring approximately 2–3 hours later than the peak in activity) appeared to be due to fewer but stronger signals;

(b) HF activity appears to peak two times per day, the major peak occurring at about 2000 e.d.t. and a second, lesser peak at about 0800 e.d.t.;

(c) though adequate statistics are not available, it appeared that maximum spectral power was observed from an easterly direction at most times of the day;

(d) analysis of the relative mean spectral power density both by direction and frequency (figure 10) showed a fairly uniform pattern indicating that the total integral power re-
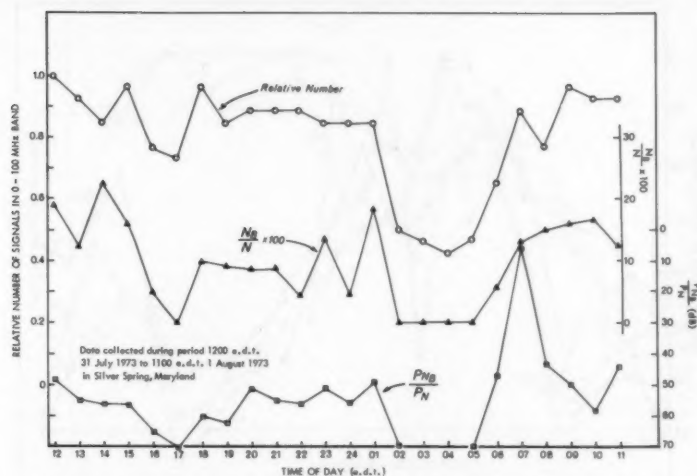
Figure 6. Relative spectral activity in the 0–100 MHz band (1 day)

ceived was approximately uniformly distributed over frequency. One exception noted was a dip in the power received from the east in the 10–14 MHz region of the band;

(e) using a long wire antenna (undefined radiation pattern), figure 11 shows the same bimodal activity and power function at 2000 and 0800 e.d.t. These data have been averaged over the period August 2–6, 1973, and indicate that over this period, the relative band activity approximately doubled at the peak times as compared to other times, while the relative integral spectral power is again 20 dB higher at its peak than otherwise;

(f) with the long wire antenna (figure 12), it was seen that over the August 2–6, 1973, period the highest relative number of signals was in the lowest 2 MHz subband between 2
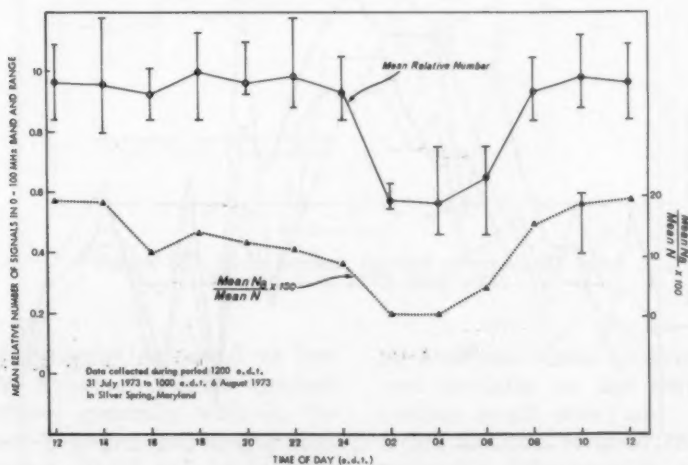
Figure 7. Mean relative spectral activity in the 0–100 MHz band (6 days)
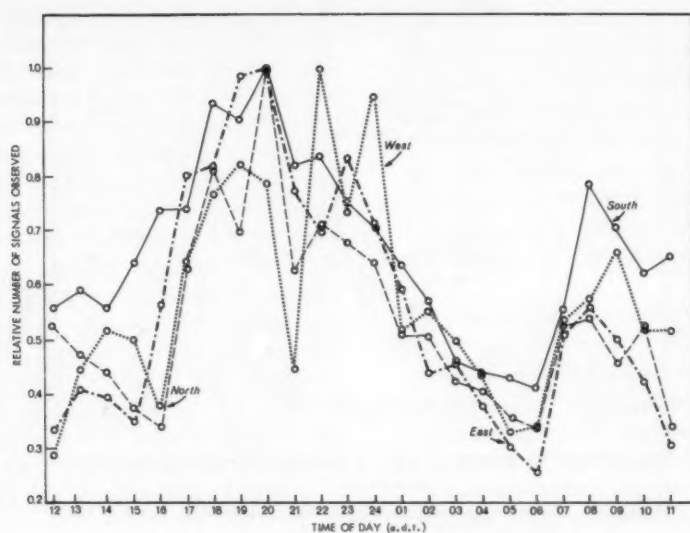
Figure 8. Relative spectral activity in the HF band
(1 day, log periodic)
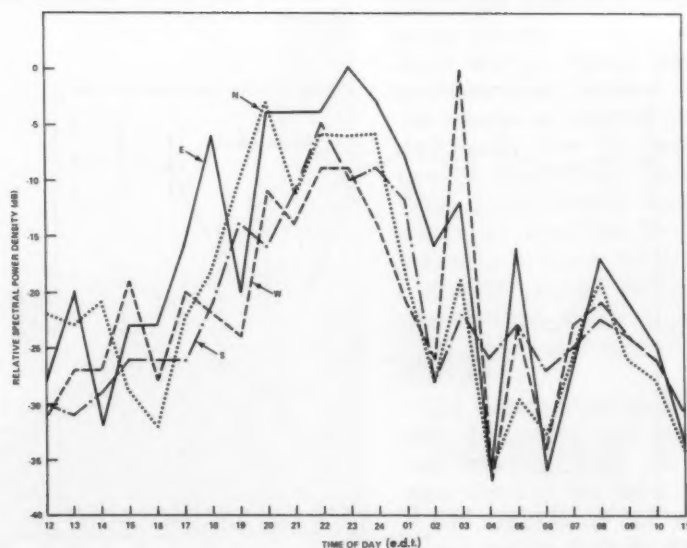
Figure 9. Relative spectral power density in the HF band
(1 day, log periodic)
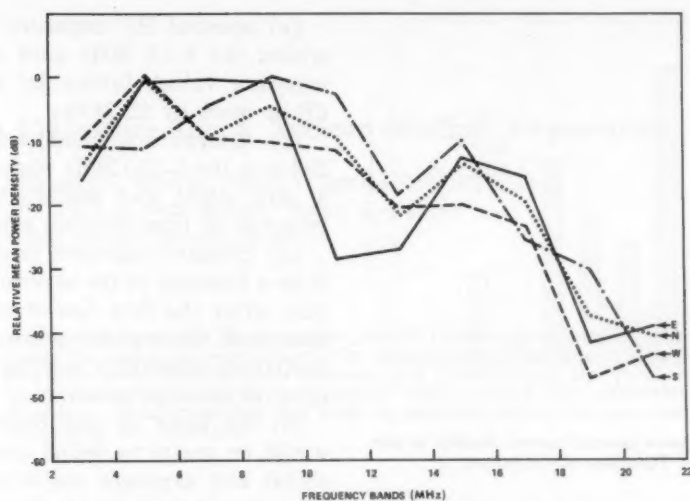
Figure 10. Relative mean spectral power density in the HF band as a function of direction (1 day)
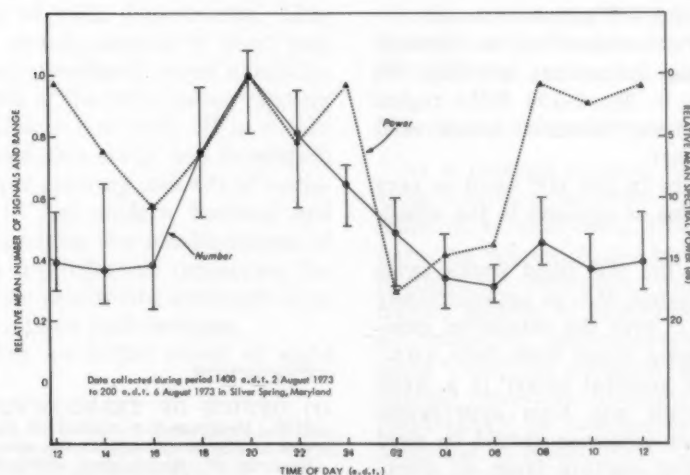
Figure 11. Mean integral spectral power in HF band (August 2–6, 1973, long wire)

and 4 MHz, and generally decreased as frequency increased. Relative integral spectral power also decreased generally with an increase in frequency but exhibited several relative peaks in the 2–4, 10–12, and 16–18 MHz subbands. These measurements, using the long wire, are representative of resultant values for

all directions since no directional information was available on the characteristics of the random length wire; and

(g) the data revealed (data not shown) no noticeable differences in activity or integral signal power as a function of the day of the week.
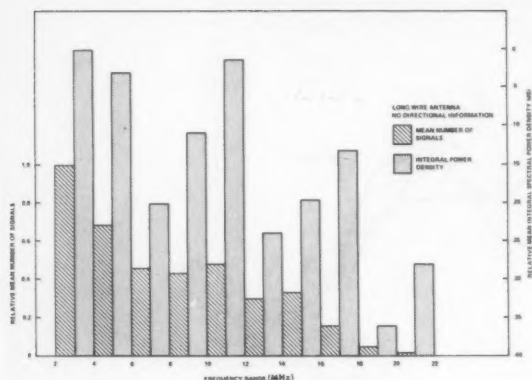
Figure 12. Relative mean spectral power density in the HF band as a function of frequency

Conclusions

Several gross indications of spectral activity in the 0–100 MHz frequency region were obtained which should prove useful for planning future environmental RF measurements:

(a) though not determined on an absolute field intensity basis, indications are that the principal exposure in the 0–100 MHz region is due to sources in the broadcast bands, AM, FM, and TV stations;

(b) signal activity in the HF band is very dynamic and unstable as opposed to the broadcast services;

(c) exposure in the HF band peaks twice per day in Silver Spring, Md., at approximately 2000 and 0800 e.d.t. with the maximum exposure usually occurring about 2000–2400 e.d.t.;

(d) integral HF spectral power is a weak function of direction and thus appropriate isotropic monitoring antennas should be used to insure total signal capture from all directions;

(e) spectral HF exposure is predominantly within the 2–18 MHz part of the band with exposure values falling by approximately 30 dB or more by 22 MHz;

(f) intermittent nonbroadcast or HF activity in the 0–100 MHz region represents only a very slight and essentially negligible contribution to total integral exposure; and

(g) primary exposure, in any band, appears to be a function of the several strongest signals (i.e., after the first few strongest signals are measured, the remaining population of signals contribute essentially nothing in terms of total integral spectral power).

On the basis of this preliminary study, it would be useful to define more accurately the signal and exposure statistics in the various frequency bands, particularly in those bands in which intermittent activity occurs. This would best be accomplished by continuous monitoring and automated data collection by computer assisted instrumentation.

REFERENCE

(1) OFFICE OF TELECOMMUNICATIONS POLICY. Program for control of electromagnetic pollution of the environment: the assessment of biological hazards of nonionizing electromagnetic radiation. Executive Office of the President, Office of Telecommunications Policy (March 1973).

An Evaluation Procedure for a Nuclear Medical Department

David Metz, MPA,[1] Stanley J. Malsky, Ph.D.,[2] Charles J. Blatt, M.D.,[3]
David B. Hayt, M.D.,[4] Arthur Frie, MPH.,[5] Peter A. Betar,[6]
John Macca, MPA,[7] and Donald Simon, M.S.[8]

This study presents administrative, health physics, educational, instrumentation and space requirements for departments of nuclear medicine. The data were recorded from answers to a questionnaire and personal interviews with personnel in hospitals with varying bed capacities. Finally, a visual inspection was made of each department by personnel conducting the interview.

A literature survey was conducted to determine if data were available relating to departments of nuclear medicine and certain plant, personnel, educational and equipment parameters that might serve as a guide in evaluating the performances of such departments. Limited data (1) to certain aspects of plant and cost (2) (or cost/procedure) were available, but not the specifics of the information relating the questions topical to our study. It is within this framework that this study was developed.

The increased and growing uses (3) of radiopharmaceuticals in the modern hospital and medical center mandates the establishment of definitive criteria and effective techniques for developing radiation monitoring and evaluating departments using these radioisotopes.

After conducting an initial study of eight radioisotope departments in hospitals of varying bed capacities, over a 12-month period, the authors have attempted to develop a method of evaluating a nuclear medical department. The study encompassed medical, administrative, educational, and health physics parameters and, therefore, includes criteria relative to all three disciplines.

Objectives of the radioisotope department

As a support service, the department provides standard accepted[9] diagnostic in vivo imaging, in vitro tests, and therapeutic procedures on request from the various clinical departments. Originally, radioisotope departments, because of the radiation factors, such as protection, measurements, and dosimetry, came under the direction of radiologists. The current consensus, however, is that the department should be directed by the best qualified specialist. A recent study (4) indicated that of the nine hospitals sampled having radioisotope departments, three of the departments are autonomous. Two of these are headed by internists and one by a radiologist. Three are operated under the Department of Radiology, two

[1] Associate director, Division of Education and Research in Community Medical Care, University of North Carolina School of Medicine, Chapel Hill, N.C.

[2] Chief medical physicist, Department of Radiology, Fordham Hospital, Southern Blvd. and Crotona Avenue, Bronx, N.Y.

[3] Chief, Department of Radiology, Fordham Hospital, Southern Blvd. and Crotona Avenue, Bronx, N.Y.

[4] Director, Department of Radiology, Misericordia Hospital, 600 East 233rd Street, Bronx, N.Y.

[5] Assistant administrator, Misericordia Hospital Medical Center—Fordham Hospital affiliation, Bronx, N.Y.

[6] Administrator, Misericordia Hospital Medical Center—Fordham Hospital affiliation, Bronx, N.Y.

[7] Assistant affiliation administrator, Misericordia Hospital Medical Center—Fordham Hospital affiliation, Bronx, N.Y.

[8] Senior physicist, Misericordia Hospital, 600 East 233rd Street, Bronx, N.Y.

[9] Standard and accepted are defined as the techniques and procedures which have been reviewed by the hospital's Radioisotope Committee and the Human Use Committee as having diagnostic/therapeutic value and approved by the New York City Office of Radiation Control Human Use Committee (not for experimental or research purposes).

under the Department of Medicine, and one under the Department of Pathology. Of the five largest hospitals examined in this study, four have radiologists in charge and one is headed by an internist.

Regardless of who directs the department, the use of radiopharmaceuticals involves special care in preparation (5), calibration (6), administration (7), and monitoring to comply with safe and acceptable radiological health standards. For reasons of safety as well as for efficiency, effectiveness, and control, it is, therefore, strongly suggested that radioisotope procedures be performed in a central location rather than fragmented among the various services. Fragmentation reduces clinical and administrative control and usually results in duplication and lack of coordination of personnel, equipment, and supplies.

To meet the objectives of supporting the clinician in the diagnosis and treatment of illness, the radioisotope department must be able to perform, interpret, and report diagnostic test results and therapeutic procedures efficiently [10] and effectively.[11] This support function must be available on a timely basis with consultation to all physicians and departments of the hospital in the following manner.

According to McAfee (8), there are eight categories of tracer methodology:

1. dynamics of the steady state,
2. transport across mucous membranes,
3. metabolic pathways and interconversions,
4. biological fate of chemically inert compounds,
5. mineral metabolism,
6. indicator dilution analysis,
7. regional blood flow, and
8. spatial diffusion.

While it is recognized that all radioisotope departments will not perform the same scope or number of services, the techniques for evaluation should be universally applicable.

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[10] Efficiency is defined as the degree to which a desired result is achieved in the shortest possible time, for the least cost, without being compromised.

[11] Effectiveness refers to the quality of results and the degree to which they enable the clinician to achieve his objectives.

Patient Dosimetry

Exposure per procedure, cumulative and approval dose record

The following factors should be considered before any radiopharmaceutical is considered for use (9–11):

1. adequate review of the desired radioisotopes by the Hospital Isotope Committee considering the appropriateness of the selected isotope.
2. the administered dose,
3. the physical, biological, and effective half-lives,
4. the deposition of the radioisotope to other tissues and organs, and
5. the age and other relevant factors (pregnancy, etc.) of the patient.

All radiation used for diagnosis (x rays and isotopes) have a certain deleterious effect. However, when employed judiciously, the effects of diagnosis (and cure of the patient) must be weighed against these effects. Calculations, experimental evidence and tables are available (12–14) so that the clinician and the Isotope Committee can evaluate all of the factors in either approving and performing a procedure or not. The physician and patient must always consider the benefits vs. risks of the disease as opposed to benefit vs. risks from diagnosis and cure. Evidence that these considerations were followed was of singular importance in this study.

Radiopharmaceuticals

Vendors of radiopharmaceuticals are regulated or follow the percepts of the U.S. Food and Drug Administration, U.S. Atomic Energy Commission or State inspection agencies. These vendors maintain quality control and guarantee both the quantity and quality of individual and lot shipments of the radioisotopes supplied to hospitals. However, as with any pharmaceutical used in a hospital, the radioisotope shipment should be calibrated on an individual basis prior to use for both the quantity (millicurie per ml)

and quality (other radionuclides). These quality control measurements ascertain the purity of the particular radionuclide to be administered. All data should be logged for reference and accountability.

"Blind" procedures

The use of calibrated samples or two sample techniques as confirmation of in vitro procedures can be employed. For in-house confirmations this may be with or without the knowledge of the person performing the test. The American Society of Clinical Pathology (15) has recently established a quality assurance service in nuclear medicine to assist individual laboratories with their internal quality control programs. These are examples of types of quality control techniques that may be employed.

Personnel

The staffing requirements of a nuclear medicine department will vary depending on the size and type of hospital, the number and types of clinical procedures performed and the equipment available (16,17). If the hospital has teaching and/or research programs, the isotope department will generally be varied clinically as well as experimentally. The scope and sophistication of the services offered will depend upon the demands and interests of the professional staff, and the resources and goals of the department and the hospital.

Regardless of the numbers of personnel on the staff, each member must have certain minimum education and experience qualifications (7,18). The nuclear physician should have as the result of either residency or postresidency training experience in a radioisotope department under the supervision of a trained nuclear medicine specialist. Technical personnel should have at least 2 years of training in posthigh school mathematics, radiological physics, statistics, nuclear detection instrumentation and applied electronics, in addition to radiation protection techniques, etc., geared toward reduction of exposure to patients and personnel (19). Further staffing requirements should involve a full-time or consulting medical physicist.

In each case, the personnel selected should possess such other skills and abilities that are identifiable with the department's functions and goals, i.e., clinical, research, teaching (20). Technicians may be trained in schools such as Manhattan College (21).

Method

The purpose of this evaluation procedure is to have a first technique, a guide or first approximation for a periodic ongoing evaluation of the efficiency and effectiveness of a radioisotope department. An initial literature search yielded some information but did not encompass the varied parameters that were considered essential for the evaluation. In order to accomplish this evaluative procedure, questionnaires were developed in collaboration with administrators, nuclear clinicians, physicists, and technicians.

At current prices, equipment for an adequate, reasonably sophisticated department, providing a broad spectrum of clinical tests, could cost between $125 000 and $175 000. Costs for the services of technologist(s), nuclear clinician, and consulting medical and physics staff could approximate one-half of the initial equipment expenditure per annum.

These costs will vary but must be considered in terms of increased demand as the department develops and offers a greater variety and complexity of tests. Before a radioisotope department is initiated or additional services are added, it is essential that thorough medical and administrative inquiry be made on total costs involved in relation to patient care as well as to the goals and resources of the hospital (22).

These questionnaires were then resubmitted to the respective individuals in their areas of specialty, discussed, refined, and then resubmitted for final approval by the same individuals. With this accomplished, the final questionnaire was then prepared and used.

The following broad areas were considered:

1. preparation-storage area,
2. instrumentation,
3. radiopharmaceuticals,

4. patient data[12] (age, sex, weight, area(s) to be studied, or treated),
5. time and motion,
6. personnel data,
7. nuclear clinical folder data[12] (results of clinical test, effectiveness of test, necessity for repetition of test, etc.),
8. patient folder data[12] (type of radioisotope, type of test, quantity of radioisotope administered, etc.),
9. radioisotope folder-clinical analysis[12] (was the test of clinical significance to the requesting physician, and/or did it serve as a link for further diagnosis, etc.), and
10. radioisotope department broad questions.

Onsite visits were made to each of the hospitals studied. Personal discussions were held with the Directors of Nuclear Medicine, staff and/or consulting physicist(s), senior technologists, and the administrator of the department.

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[12] Not reported in this study but it is the basis of a separate administrative paper.

Survey Findings

Space

A modern clinical radioisotope facility requires approximately 37 m² (400 square feet) of operational area exclusive of office, secretarial, dressing, and waiting room space. This area should be divided to provide for radiosotope and clinical preparation, isotope storage, calibration and health physics services. In addition, two or more patient examining rooms are needed to contain the various imaging equipment.

Table 1 presents the survey findings with respect to overall space allocations for the eight hospital isotope departments studied (200 to 1000 beds). For the small hospital (200 beds), this operational space was 30 m² (320 square feet) with an additional 46 m² (490 square feet) for other space requirements. In contrast, a 1000 bed hospital had 100 m² (1100 square feet) of operational space with an additional 86 m² (930 square feet) devoted to other space requirements.

Table 1. Summary findings of radioisotope audit area requirements

	Hospital							
	1	2	3	4	5	6	7	8
Number of beds	400	350	200	600	300	200	400	1 000
Approximate area (m² in radioisotope department):								
Preparation area	9.2	9.2	7.4	7.4	9.2	5.6	6.5	14
Storage area	2.3	2.8	7.4	3.7	6.5	2.3	6.5	9.2
Supply area	2.3	2.3	1.9	2.3	2.8	2.8	9.2	23
Imaging:								
Rectilinear	12	14	10			15	19	19
Camera	12	20.4		13.0	28		19	28
Health physics area	7.4	7.4	2.8	5.6	7.4	2.8	4.6	9.2
Subtotal	45.2	56.1	29.5	32.0	53.9	28.5	64.8	102
Waiting room	7.4	5.6	4.6	6.5	9.2	5.6	9.2	9.2
Conference room	9.2	9.2	6.5	11	9.2	7.0	9.2	14
Reading room	7.4	14	9.2	9.2	9.2	7.4	7.4	9.2
Physician's office	14	14	11	11	23	11	10	14
Physicist's office	a 14	a 14		9.2	a 11			23
Lead technician area	4.6	4.6	4.6	6.5	6.5	4.6	7.4	7.4
Secretary area	9.2	16.7	9.2	9.2	9.2	7.4	9.2	9.2
Subtotal	65.9	78.1	45.1	62.6	77.3	43.0	52.4	86.0
Total area	110	134	75	95	131	72	117	188
Radioisotope area in a single location	yes	yes	yes	yes	yes	no	yes	yes

a Shared room.
b Two secretaries.

Table 2. Summary findings of radioisotope audit: instrumentation

	Hospital							
	1	2	3	4	5	6	7	8
Imaging:								
Rectilinear:								
Age (years)	7	5	2	--------	--------	1	5	5
Purchase or lease	P	P	P	--------	--------	P	P	P
Crystal size (cm)	13	13	8	--------	--------	8	13	13
Number available	1	1	1	--------	--------	1	2	2
Calibrated	Daily	Daily	Daily	--------	--------	Daily	Daily	Daily
Down time /yr (d = days)	3 d	1 d	5 d	--------	--------	1 d	2 d	1 d
Camera								
Age (years)	5	4	--------	4	5	--------	1	5
Purchase or lease	P	P	--------	P	P	--------	P	P
Number available	1	1	--------	1	1	--------	1	1
Calibrated	Daily	Daily	--------	Daily	Daily	--------	Daily	Daily
Down time /yr (d = days)	• 90 d	3 d	--------	4 d	3 d	--------	2 d	3 d
Radioisotope calibrator:								
Age (years)	3	2	2	3	2	1	3	3
Purchase or lease	P	P	P	P	P	P	P	P
Number available	1	1	1	1	1	1	1	1
Calibrated	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily
Down time /yr (d = days)	0 d	1 d	1/2 d	3 d	5 d	1 d	1 d	1 d
Scalers:								
Age (years)	6–10	8	2	5	3–7	1	3–8	4–10
Purchase or lease	P	P	P	P	P	P	P	P
Number available	2	1	1	1	3	1	3	5
Calibrated	Daily	Daily	Daily	Daily	Daily	Daily	Daily	Daily
Down time /yr (d = days)	2 d	1 d	1 d	1 d	3 d	1 d	3 d	5 d

• Budgetary considerations, a limiting factor.

Equipment

Table 2 summarizes equipment available in each hospital. In only one hospital, which had 250 beds, was spectral analysis performed for the gamma emitters to determine if other radioisotopes were present. All departments had and used a radioisotope calibrator. All departments owned rather than leased their equipment. One of these hospitals did, however, lease the proposed equipment for one or more months prior to purchase in order to determine equipment suitability for the department.

One radioisotope department had a down-time of over 90 days for the gamma camera. This was because of initial failure to establish adequate temperature controls for the crystal which should have been considered as part of the initial capital costs.

Health physics

Table 3 summarizes the basic health physics data accumulated. It is interesting to note that the pocket ionization chamber was not used in a single radioisotope department. Thermoluminescent dosimetry (TLD) was routinely in use in two institutions, with one of these using TLD's for the finger monitoring by personnel. Radiation posting procedures were correctly observed in varying forms in all departments. Lead cubicles and/or containers containing the isotopes were properly identified.

All radioisotopes were logged; for seven of the eight radioisotope departments, the logging was in a looseleaf folder. The eighth department had a bound book. All radioisotope departments had a formal isotope committee and a designated radiation safety officer.

Table 3. Summary findings of radioisotope audit: health physics

	Hospital							
	1	2	3	4	5	6	7	8
Personnel monitoring:								
All radioisotope personnel	yes	yes	yes	yes	yes	yes	yes	yes
Film badges used	yes	yes	yes	yes	yes	yes	yes	yes
Thermoluminescent dosimetry	no	yes	no	no	no	yes	no	no
Pocket ionization chamber	no	no	no	no	no	no	no	no
Preparation area:								
Radiation posting	yes	yes	yes	yes	yes	yes	yes	yes
Shielding of radioisotopes	yes	yes	yes	yes	yes	yes	yes	yes
Radioisotope calibrator	yes	yes	yes	yes	yes	yes	yes	yes
(available)	yes							
Log-in, log-out radioisotopes		yes	yes	yes	yes	yes	yes	yes
Emergency procedures posted	yes	yes	yes	yes	yes	yes	yes	yes
Survey equipment available:								
Number available	1	1	3	2	2	2	3	3
Number functioning	1	1	3	2	2	2	2	2
Calibrated	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Storage area:								
Radioisotope stored in:								
Adequate containers	yes	yes	yes	yes	yes	yes	yes	yes
Cubicles	yes	yes	yes	yes	yes	yes	yes	yes
Other								
Log of stored radioisotopes	yes	yes	yes	yes	yes	yes	yes	yes
Water disposal:								
Commercial service	yes	yes	yes	yes	yes	yes	yes	yes
Log of disposal	yes	yes	yes	yes	yes	yes	yes	yes
Radioisotope committee:								
Functioning	yes	yes	yes	yes	yes	yes	yes	yes
Minutes available	yes	yes	yes	yes	yes	yes	yes	yes
Radioisotope shipments:								
Radioisotope returned within last 2 years	no	yes	yes	no	no	yes	yes	yes
Radioisotope returned within last year	no	no	no	no	no	no	no	no
Quality control:								
Spectral analysis performed:								
Routinely	no	yes	no	no	no	no	no	no
In doubtful cases	no	yes	no	no	no	yes	yes	yes
Radiation safety officer (RSO):								
Designated	yes	yes	yes	yes	yes	yes	yes	yes
Is RSO:								
Clinician	no	no	no	no	no	no	no	no
Physicist	yes	yes	yes	yes	yes	yes	yes	yes
Lead technician	no	no	no	no	yes	no	yes	no

* All functioning survey meters were calibrated within the last year.

All eight hospitals had the consulting physicist as the radiation safety officer, a full-time nuclear technologist serving as his immediate representative. The technologists serving as the alternate for the health physicist did have additional formal and practical training required for the specific job.

Education

The educational backgrounds of all personnel are summarized in table 4. In the case of the nuclear clinicians, all had their specialty board certifications. Seven of the eight directors were certified by the American College of Radiology and one by the Board of Internal Medicine. One director held certification in the ACR and American Board of Nuclear Medicine. In two of the smaller hospitals just initiating a nu-

clear medicine department, the physician in charge spent from one-quarter to one-fifth of his weekly time in the department. Both of these clinicians had indicated that, as the patient load increased, either they or their delegated physician would spend additional time until there was a full-time nuclear technician.

In six hospitals there was more than one physician with responsibility for nuclear medicine, their total aggregate time being more than 40 hours per week. All hospitals had medical and/or health physicists serving in a consulting capacity. One of the hospitals had a full-time physicist. Only three of the eight physicists were certified, and this was by the American College of Radiology. All technologists had high school diplomas. A number of both the lead technologists and staff technologists had

	Hospital							
	1	2	3	4	5	6	7	8
Physician:								
Number available	2	2	1/2	1/2	1	1/4	1	3
Board certified	yes	yes	yes	yes	yes	yes	yes	yes
Which board a	ACR	ACR, ABMN	ACR	ACR	ACR	ACR	ABIM	ACR
Years of experience in nuclear medicine	b 4	b 6	3	5	5	1	6	b 10
Total number of h/wk devoted to nuclear medicine	40	40	20	20	40	10	40	90
Physicist available:								
Part-time	yes	yes	yes	yes	yes	yes	yes	no
Full-time	no	no	no	no	no	no	no	yes
Board certified	no	no	no	yes	no	no	yes	yes
Which board				ACR			ACR	ACR
Years of experience:								
In medical physics	20	22	20	20	8	20	15	15
In nuclear medicine (part of total time of medical physics above)	4	2	5	5	8	5	7	10
Number of h/wk devoted to nuclear medicine	15	10	2	8	10	2	4	30
Lead technologist:								
Licensed in nuclear medicine	yes	no	no	no	no	no	yes	yes
High school diploma	yes	yes	yes	yes	yes	yes	yes	yes
Associates degree	yes	(c)	(c)	no	(c)	no	yes	yes
Bachelor's degree	(c)	no	no	no	no	no	no	yes
Years of experience:								
Nuclear medicine	7	5	3	3	8	1	6	8
Technologists (excluding lead):								
Number available	2	3	0	0	2	0	3	4
Licensed in nuclear medicine	0	0	0	0	0	0	0	1
Number with high school diploma	2	3	0	0	2	0	3	4
Number with associate degree	(1)	(3)	0	0	(1)	(1)	(2)	2
Number with bachelor's degree	0	0	0	0	0	0	0	0

a ACR, American College of Radiology
[ABNM, American Board of Nuclear Medicine
ABIM, American Board of Internal Medicine.
b Average number of years.
c In progress.

or were preparing for an associate or higher degree (21).

Time and motion per procedure

Table 5 shows a time and motion study available from one hospital which had attempted to assign average time factors for each of the examinations it had been conducting. It should be noted that the other nuclear medical departments expressed concern for the time and motion aspects and did state that they had general figures regarding the average time per procedure but that it had not been formalized. While it is realized that newer instrumentation or revised radiopharmaceuticals will replace existing systems, the table presented does provide a guide to total time employed per procedure. Further, it is realized that each radioisotope department will develop its own time and motion study. This guide may be at variance with the table presented here; however, such a table will provide the technician, clinician and administrator with an approximation as to average time to be anticipated per procedure.

Summary

A broad based questionnaire was prepared by a team composed of administrators, radiologist, physicists and technologists, dealing with a number of parameters in nuclear medicine. Summary data for a number of these areas are presented in this report.

Future work

It is realized that this survey, reported here in part, is a first attempt to relate a number of medical, administrative, technical, health physics, and patient parameters. It is hoped that from this initial effort, refinement, criticism and revisions will result in a final audit guide applicable to all nuclear medicine departments.

Table 5. Summary findings of radioisotope audit time and motion; in vitro and camera procedures

Type of examination	Time to prepare patient set-up[a] (minutes)	Time to prepare radioisotope[b] (minutes)	Procedure time[c] (minutes)	Level of difficulty[d]	Number of procedures (minutes)	Total time[e] (minutes)
Brain [f]	15	6	6	6	5 (30 min)	e 51
Liver [h]	15	20	5	5	4 (20 min)	e 55
Renal scan [i]	15	15	15	3	3 (45 min)	e 75
Renogram	15	6	30	2	1 (30 min)	e 56
Spleen	15	20	5	2	3 (15 min)	e 50
Heart [f]	15	6	6	4	3 (18 min)	e 39
Schilling test	15	10	45	2	1 (45 min)	e 70
Placenta	15	6	10	2	2 (20 min)	e 41
Blood volume	20	10	30	3	1 (30 min)	e 60
Lung [h]	15	6	7	6	6 (42 min)	e 63
RBC	55	15	20	5	2 (40 min)	e 110
T-3's	120	15	30	3	2 (60 min)	e 195
T-4's	180	15	15	6	2 (60 min)	e 255
Thyroid uptake	10	10	10	2	2 (20 min)	e 40
Bone [m]	35	6	20	10	4 (80 min)	e 121
Fat absorption	30	15	120	5	1 (120 min)	e 165
Thyroid scan	15	6	15	3	1 (15 min)	e 36
Liver function	15	6	15	5	5 (75 min)	e 96
59Fe kinetic	30	6	15	5	6 (90 min)	e 156
Digoxin [n]	90			8		e 180
Angiotensin [n]	60			10		e 360

[a] Prepare patient from the time patient comes in room for scan. This is an *average time*, some patients are easier to work with, some more difficult.
[b] Prepare radioisotope: to take radioisotope from storage area, or withdraw liquid radioisotope solution (calibrate liquid quantity).
[c] Actual time from administration of radioisotope to obtaining data and confirming results obtained, prior to the release of patient.
[d] Level of difficulty: 1, the easiest; 10, the most difficult.
[e] Transportation time of patients was not included in these estimates. One can assume 30–40 minutes delay (average 30 minutes).
[f] Dynamic study performed with brain and heart scans. One film every 3 seconds for a total of eight films in 24 seconds.
[g] This does not include any time (estimate from 5 minutes to 1/2 hour) to obtain physician. Procedure times are subject to change with the development of new agents.
[h] Agent used was technetium-99m sulfur colloid.
[i] Agent used was technetium-99m D.T.P.A.
[k] Agent used was iodine-131 M.A.A.
[m] Agent used was strontium-85.
[n] Time for six tests.

REFERENCES
(1) THE LANCET. Editorial, Radioisotope services. The Lancet (October 10, 1970) pp. 760–761.
(2) TABERN, D. L. What are realistic radioisotope charges. Modrn Hosp 105: 118–120 (November 1965).
(3) U.S. ATOMIC ENERGY COMMISSION. The nuclear industry, 1970. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (1970).
(4) WILSON, J. A. Analysis of radioisotope units in nine general hospitals. Hospital Topics: 53–61 (May 1966).
(5) KONNEKER, W. R. Radiopharmaceutical quality control, reduction of radiation exposure in nuclear medicine, PHS Publication No. 999–RH–30. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (December 1967) pp. 77–87.
(6) NATIONAL BUREAU OF STANDARDS. Precision measurement and calibration, NBS Handbook 77, Vol. III. U.S. Department of Commerce, Washington, D.C. (1961).
(7) COOPER, J. F. and G. D. SCHMIDT. Recent developments by standards-setting institutions in nuclear medicine. Presented at the American Public Health Association meeting, Minneapolis, Minn. (October 14, 1971).
(8) McAFEE, J. G. Reduction of radiation exposure in nuclear medicine, PHS Publication No. 999–RH–30. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (December 1967).
(9) WELLMAN, H. N., and E. L. SAENGER. Prospects for dose reduction and assessment in nuclear medicine. Presented at the American Public Health Association meeting, Minneapolis, Minn. (October, 14, 1971).
(10) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Radiosensitivity and spatial distribution of dose, ICRP Publication No. 14. Pergamon Press, New York, N.Y. (1969).

(11) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. The evaluation of risks from radiation, ICRP Publication No. 8. Pergamon Press, New York, N.Y. (1968).
(12) JOHNS, H. E. The physics of radiology. C. C. Thomas. Publishers, Springfield, Ill. (1967).
(13) FIELDS, T., and L. SEED. Clinical use of radioisotopes, a manual of technique. Yearbook Publishers, Chicago, Ill. (1961).
(14) SILVER, S. Radioactive nuclides in medicine and biology. Lea and Febiger, Philadelphia, Pa.
(15) AMERICAN SOCIETY OF CLINICAL PATHOLOGY. American Society of Clininical Pathology, 2100 West Hollison Street, Chicago, Ill. 6612.
(16) BENDER, M. A. Should your hospital have a nuclear medicine unit. Hosp Practice: 43–54 (February 1967).
(17) BRUCE, M. Radioisotopes in the diagnosis and treatment of cancer. Prog Clin Cancer I: volume I: 74–95 (1965).
(18) FOOD AND DRUG ADMINISTRATION. Nuclear medical technology training. U.S. Department of Health, Education, and Welfare, Food and Drug Administration, Washington D.C. (June 1971).
(19) MOELLER, D. W. Meeting radiological health manpower needs. Amer J Pub Health 61:1938–1945 (October 1971).
(20) DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE. Medical radiation information for litigation, a symposium, DMRE, 69–3. U.S. Department of Health, Education, and Welfare, Washington, D.C.
(21) MALSKY, S. J., C. G. AMATO, and G. J. CROWE. A two-year radiological institute: five-year summary and future trend. Amer J Pub Health 60: 2102–2109 (November 1970).
(22) JOINT COMMIMSSION ON ACCREDITATION OF HOSPITALS. Policy statement on medical care evaluation and utlization review, Bulletin No. 62. Joint Commission on Accreditation of Hospitals (Fall 1971).

Significance of Stable Iodine-127 in Milk

William J. Kelleher and Harvey R. Prins [1]

The unexpected high concentrations of stable iodine in milk found when studying the specific activity concept for iodine-129 around a nuclear fuels reprocessing plant led to an evaluation of the use of iodine-129 to iodine ratio in milk samples to calculate population doses. In order to use specific activity to calculate thyroid dose, it will be necessary to establish values for the concentration of iodine in thyroids. If a constant concentration of iodine in the thyroid is assumed and there is a high enough concentration of iodine in the milk to be able to assume that milk is the only source of iodine in the thyroid, a relationship between thyroid dose and iodine-129 to iodine or iodine-131 to iodine ratios can be developed. The use of specific activity in milk to determine dose will have the greatest application in evaluating the man-rem dose from the discharges of iodine-129 from fuel processing plants.

In the calculation of yearly dose to the thyroid of a member of the public from the ingestion of milk containing radioiodine, the concentration of stable iodine in the milk is usually ignored. An uptake factor of 0.3 in accordance with International Commission on Radiological Protection (ICRP) (1) recommendations is generally used. However, if the milk contains a sufficient concentration of stable iodine-127, the thyroid uptake factor for iodine could be less than 0.3. If milk is the only source of iodine in the body, then the ratio of iodine-131 or iodine-129 to total iodine in the human thyroid could not be higher than that found in the milk.

Specific activity concept

The use of specific activity, iodine-129/iodine, has been discussed by Bryant (2), Russell and Hahn (3), and Tadmor (4) in evaluating the potential hazards to the public from iodine-129 released at fuel reprocessing plants. The authors discussed the assumption that the iodine-129 and iodine-127 continuously released would reach equilibrium with the natural iodine-127 present in the environment and the maximum possible dose to the thyroid might be predicted from the iodine-129 to iodine ratio found in environmental samples. A critical environmental pathway, milk, might be evaluated by the conservative assumption that a continuous routine atmospheric release of iodine-129 would reach equilibrium with naturally occurring iodine in the air and the ratio of iodine-129 to iodine would reach equilibrium throughout the environmental pathways to milk. The maximum possible dose to the thyroid from deposition on pasture land would be unlikely to exceed the dose predicted by the iodine-129 to iodine ratio in the air. The authors recognized that sources of iodine-127 other than air could lower the ratio, but no natural environmental method for increasing the ratio could be predicted.

The finding of iodine-129 in milk and other environmental samples around the Nuclear Fuel Services (NFS) Reprocessing Plant in New York State has been reported by the New York State Department of Environmental Conservation (NYSDEC) (5,6). The U.S. Environmental Protection Agency (EPA) also conducted cooperative studies around NFS (7,8) and confirmed the presence of iodine-129 in milk and other samples due to atmospheric releases. EPA provided funding to the NYSDEC

[1] New York State Department of Environmental Conservation, Albany, N.Y. 12201.

Table 1. Iodine-127 concentrations in milk

Farm	Date	^{127}I (µg/liter)	Farm	Date	^{127}I (µg/liter)	Farm	Date	^{127}I (µg/liter)
14	8/14/71	[a] 159	31	2/6/73	233	51	3/6/73	2
	12/4/72	[b] 4 626		6/12/73	[c] <1		4/18/73	<1
	12/14/72	610		8/14/73	27		7/17/73	39
	1/7/73	417		9/19/73	42		10/25/73	45
	2/6/73	371		10/25/73	21		11/29/73	78
	3/6/73	232		11/29/73	185		12/27/73	1 639
	4/18/73	354	43	12/4/72	285	68	1/7/73	243
	5/9/73	433		3/6/73	31		4/18/73	59
	6/12/73	65		4/18/73	273	96	1/7/73	5 670
	7/17/73	49	45	8/14/72	74		2/6/73	2 183
	9/19/73	100	45A	2/6/73	390		6/12/73	1 099
	10/25/73	45		3/6/73	706		7/17/73	3 587
	11/29/73	72		9/19/73	162		8/14/73	960
	12/27/73	418	46	5/9/73	344		9/19/73	1 104
	2/5/74	1 124	49	5/9/73	1 292		10/25/73	1 418
31	12/4/72	98	50	5/9/73	1 827		11/29/73	264
	1/7/73	223		8/14/73	354		2/5/74	721

Errors of 2 standard deviations are approximately:
  [a] ± 7 percent.
  [b] ± 2 percent.
  [c] ± 100 percent.

to support a further study of iodine-129 in milk and requested an evaluation of the specific activity concept as applied to the NFS site. The study required that both iodine-129 and iodine-127 be measured in milk by neutron activation. The results of the study were reported by Kelleher and Michael (9).

Iodine-127 in milk around a fuel reprocessing plant

The NFS plant was shut down in November 1971, and probably no significant releases of iodine-129 occurred after that time. The study indicated no buildup of iodine-129 in the local milk supplies because of the weathering of previously deposited iodine-129. The study revealed unexpected high concentrations of iodine-127 in many of the milk samples and a wide range of iodine-127 in milk from <1 µg/liter to 5 700 µg/liter. Table 1 gives the concentrations observed at different farms.

The difference in iodine-127 concentrations in milk from one farm to another around the NFS plant can be accounted for by varying farming practices. One of the most important factors is the amount of medicated or trace mineralized salt containing iodine-127 added to the cow's diet (9). An investigation of iodine-127 concentrations in milk supplies in other areas of New York State and their variances with the season is planned to ascertain if the findings pertaining to the milkshed around NFS are similar throughout the State. Infor-

mation from a few interviews outside the NFS area indicate that ethylene diamine dihydroiodide, EDDI, is routinely used by many dairy farmers in the State to prevent foot rot which is a problem in cold damp climates.

The concentrations of iodine-127 in cow's milk around the NFS area are related to outside sources of iodine-127, farming practices, and seasonal variations and have little relationship to natural iodine in the air. Therefore, the use of iodine-129 to iodine ratio in air assuming equilibrium conditions to obtain dose from the ingestion of milk appears to be highly conservative. However, the ratio of iodine-129 to iodine actually found in milk samples to assess the maximum possible yearly thyroid dose from consumption of milk might be used if the concentration of iodine in the milk is high enough to assume it is the only source of iodine found in the thyroid.

Proposed U.S. Atomic Energy Commission (AEC) guidelines (10) for light-water nuclear power plants require that iodine-131 in milk be measurable down to a level of 0.5 pCi/liter in order to demonstrate that the maximum possible infant thyroid dose will not exceed 15 mrem per year. The AEC guide (11) for analysis of iodine-131 in milk requires that iodine be added and the chemical yield determined. In order to find chemical yield, the amount of iodine already in the milk should also be determined. It is expected that the AEC will also develop guidelines for iodine-131 and iodine-129 at fuel reprocessing plants with similar require-

ments for detection of low levels of radio-iodines. In neutron activation analysis for iodine-129, iodine-127 can also be readily determined.

Evaluation of iodine-127 in milk

Since the tests for radioiodine in milk may also require a total iodine determination, it is appropriate to examine the iodine-129 or iodine-131 to iodine ratio to ascertain what the maximum possible dose could be. The ICRP (1) model for dose determination and the FRC (12) recommendations as to dose from ingestion of iodine-131 will be used. Matuszek et al. (13) have recommended a re-evaluation of the dosimetry of iodine-129 in the thyroid gland particularly the effect of high-LET Auger electrons. The purpose of this paper is to look at possible uses of specific activity on individual milk samples and not to develop changes in relation between thyroid burdens and doses recommended in the 1959 ICRP Report (1).

The FRC and ICRP data to be used in the calculations of ratios are as follows unless otherwise stated:

m = mass of thyroid = 2 grams for infant, 20 grams for adult,

T_b = biological half-life of iodine in thyroid = 138 days,

f_w = fractional uptake by thyroid gland = 0.3,

T_e = effective half-life = 7.6 days for iodine-131 and 138 days for iodine-129,

t = time in days,

C = concentration of iodine in thyroid in $\mu g/g$ = 350 $\mu g/g$ for adult or child (note that C is not used in the 1959 ICRP report to determine maximum allowable concentrations),

I = μg of iodine,

I_d = daily intake of iodine ($\mu g/day$),

ξ = effective absorbed energy per disintegration in the thyroid gland (MeV) = 0.22 for iodine-131 and .068 for iodine-129,

P_d = daily intake of radionuclide in pCi/day,

R = allowable weekly dose in rem/week, and

D = allowable yearly dose in mrem/year.

Iodine-129 to iodine ratio

The use of a radioiodine to iodine ratio to predict yearly thyroid dose has its greatest application for the long-lived radionuclide iodine-129 where the physical half-life of 17 million years results in the effective half-life and biological half-life being the same. Therefore, the rate of elimination of iodine-129 and iodine from the thyroid are the same simple exponential function of time used in the ICRP model.

In the proposed use of specific activity in milk to determine thyroid dose, the iodine-129 to iodine ratio in the thyroid is assumed to be the same as in the milk. The concentration of iodine-129 in the thyroid is determined by multiplying iodine-129 to iodine ratio in the milk by the concentration of iodine "C" in the thyroid. Dose is then determined in the conventional manner from the thyroid burden of iodine-129 per mass of thyroid tissue. The specific activity method of dose calculation presently proposed depends on a constant "C", the concentration of iodine in the thyroid, and, as will be demonstrated, the maximum possible dose from iodine-129 can be calculated without using the uptake factor, biological half-life, or the amount of milk consumed.

In order to illustrate the application of the ratio concept, the commonly used method of dose determination will be used which assumes an uptake factor of 0.3.

The daily requirement of an infant, assuming equilibrium where the rate of intake equals the rate of elimination, would be:

$$I_d = \frac{0.693 \, mC}{f_w \, T_b}$$
$$= \frac{(0.693)(2)(350)}{(0.3)(138)} = 11.7 \, \mu g/day \quad (1)$$

The allowable intake of iodine-129 not to exceed 0.5 rem per year dose to the thyroid, assuming equilibrium, would be as follows:

$$P_d = \frac{2.8 \times 10^3 \, mR}{\xi \, f_w} \quad \frac{0.693}{T_e}$$
$$= \frac{(2.8 \times 10^3)(2)(9.61 \times 10^{-3})(0.693)}{(.068)(0.3)(138)}$$
$$= 13.2 \, pCi/day \quad (2)$$

Equilibrium was assumed for total iodine and iodine-129 because the rate of elimination from the thyroid is the same for both and it is assumed that the thyroid was only exposed to the same iodine-129 to iodine ratio. Also, it should be noted that, at equilibrium, the dose to the thyroid for a given continuous daily intake of iodine-129 will be at the maximum.

If a child drinks 1 liter per day, then the allowable ratio of iodine-129 to iodine in milk so as not to exceed 0.5 rem per year to the infant thyroid is:

$$\frac{^{129}I}{I} = \frac{13.2 \text{ pCi/liter}}{11.7 \text{ } \mu g/\text{liter}} = 1.1 \frac{\text{pCi}}{\mu g} \quad (3)$$

If equations (1) and (2) were to be solved simultaneously by dividing P_d by I_d, R would be related to the ratio as follows:

$$R = \frac{\xi C}{2.8 \times 10^3} \frac{P_d}{I_d} \text{ and}$$
$$D = 18.6 \text{ } \xi C \frac{^{129}I}{I} \text{ in mrem/yr} \quad (4)$$

As previously explained, the formula simply states that the concentration of iodine-129 in the thyroid is determined by multiplying the iodine-129 to iodine ratio in milk by the concentration of iodine in the thyroid, and dose is determined from the burden of iodine-129 per mass of thyroid. For $C = 350 \text{ } \mu g/g$, $\xi = .068$ MeV and iodine-129 to iodine ratio in milk used $D = (18.6) \text{ } (.068) \text{ } (350) \text{ iodine-129/iodine} = 440 \text{ iodine-129/iodine}$.

The major advantage of the specific activity for iodine-129 in milk is that uptake factor, biological half-life, amount of milk consumed, amount of iodine in the diet do not enter the dose calculation. The major disadvantage is that the dose can be underestimated if the value of "C" chosen is too low or if "C" increases as the amount of iodine in the diet increases. If specific activity is to be used, it will be important to establish a relationship between "C" and iodine in the diet.

Le Blanc et al. (14) found that normal adult thyroid tissue obtained from autopsy specimens was 980 μg of iodine per gram of thyroid.

The authors attributed a lowering of the uptake factor for iodine-131 to an increase of iodine in the diet in the Houston, Tex., area. In a Battelle report (15) where different values for "C" were used for four age groups, it was concluded that the limiting iodine-129 to iodine-127 ratio would be based on the adult thyroid because of a higher "C" for the adult (350 $\mu g/g$) as compared to 90 $\mu g/g$ for the one year old.

The use of specific activity for iodine-129 in milk is not recommended for the design or control of nuclear fuel reprocessing plants. A decision on the part of the dairy farmer to eliminate the use of EDDI (ethylene diamine dihydroiodide) in the cow's diet could drastically lower the iodine-127 found in the milk. The present model for dose assessment using an uptake factor of 0.3 and biological half-life of 138 days appears to be appropriate for design and control purposes.

Specific activity of iodine-129 in milk can be used for estimating the actual impact of an operating nuclear facility. This is especially important when one is comparing alternate environmental pathways to determine which source of radioiodine, inhaled or ingested, gives the greatest thyroid dose. The actual aggregate man-rem thyroid dose from iodine-129 as calculated from specific activity will be much less than the value calculated using the conventional model in those areas where the dairy farmers add EDDI to the diet of cows. Analyses of milk from individual dairy farms and pooled milk from milk receiving plants will give the necessary data to use specific activity to determine man-rem dose.

An example of the use of the ratio concept is given in table 2 where an allowable dose of 500 mrem/year and a value of $C = 350 \text{ } \mu g/g$ are assumed. A comparison is made to an extrapolation of the FRC recommendation for iodine-131 to iodine-129. The use of a value of $C = 1 000 \text{ } \mu g/g$ instead of 350 $\mu g/g$ would require that the dose be multiplied by a factor of 2.9 or the allowable concentration reduced by a factor of 2.9 when using specific activity to calculate dose.

The use of the ratio to predict dose from iodine-129 below 10 μg/liter of iodine in the

Table 2. Allowable concentration iodine-129 versus concentration of iodine

(For 500 mrem per year dose and C = 350 μg/g)

Actual μg iodine/liter of milk	Allowable concentration of iodine-129 (pCi/liter)	
	From ratio ^{129}I/I	From FRC [a]–ICRP
10	11	16
20	23	16
40	45	16
100	110	16
500	570	16

[a] The Federal Radiation Council's recommendations for iodine-131 intake were extrapolated to iodine-129 using 80 pCi/liter as an allowable iodine-131 concentration and multiplying this by the ratio of maximum permissible concentrations of iodine-129 to iodine-131 for a 168-hour week as found in the 1959 ICRP report.

milk is not recommended because the methods for iodine determination, except for neutron activation, would probably give an error of around ±10 μg/liter for two standard deviations and the statistics using the ratio would be very poor. If the milk is consistently less than 10 μg/liter for iodine then the conventional method of dose determination assuming an uptake factor of 0.3 should be used.

In looking at iodine-131, the concept of determining dose from the ratio in milk must be approached with great caution because a lower biological half-life for iodine will require a proportionately higher amount of iodine in the diet, but will not lower the dose proportionately.

Burnett (*16*) has demonstrated that FRC calculations show 74 pCi/day corresponding to a dose to the infant thyroid of 500 mrem per year. The assumption of equilibrium can be made because "t" is much greater than T_e. The value of 74 can be computed from the previous equation as follows:

$$P = \frac{2.8 \times 10^3 \, \text{mR}}{\xi \, f_w} \frac{0.693}{T_e}$$

$$= \frac{(2.8 \times 10^3)(2)(9.61 \times 10^{-3})(0.693)}{(.22)(.3)(7.6)} \quad (5)$$

$$= 74 \, \text{pCi/day}$$

The ratio of iodine-131 to iodine for 500 mrem per year infant thyroid dose for an intake of 1 liter per day comes out to be:

$$\frac{74 \, \text{pCi/liter}}{11.7 \, \mu\text{g/liter}} = 6.3 \, \text{pCi}/\mu\text{g} \quad (6)$$

If specific activity were to be used to calculate dose and there was 100 μg/liter of iodine-127, the amount of iodine-131 to give a dose of 500 mrem/year would be 630 pCi/liter instead of 80 pCi/liter.[2]

A more realistic approach to the use of the iodine-131 to iodine ratio would be to use a biological half-life of 20 days for the infant and still use a concentration of iodine in the thyroid of 350 μg/g as follows:

Daily iodine requirement

$$I_d = \frac{(0.693)(2)(350)}{(0.3)(20)} = 81 \, \mu\text{g/day} \quad (7)$$

The corresponding allowable concentration of iodine-131 for a 20 day biological half-life to produce a thyroid dose of 500 mrem/year is 99 pCi/liter. The corresponding ratio is:

$$\text{Ratio} = \frac{99}{81} = 1.2 \, \frac{^{131}\text{I}}{\text{I}} \text{ in pCi}/\mu\text{g} \quad (8)$$

The direct substitution in the formulas as was done for iodine-129 yields a relationship between dose and ratio as follows:

$$R = \frac{\xi \, C}{2.8 \times 10^3} \frac{T_e}{T_b} \frac{P_d}{I_d} \text{ or}$$

$$D = 18.63 \, \xi C \frac{T_e}{T_b} \frac{P_d}{I_d} \, \text{mrem/yr}$$

$$= (18.6)(.22)(350)\left(\frac{5.7}{20}\right) \frac{P_d}{I_d}$$

$$= 408 \, \frac{^{131}\text{I}}{\text{I}} \quad \text{(for } T_b = 20 \, \text{d, \& } C = 350 \, \mu\text{g/g)}$$

$$(9)$$

Table 3 gives an allowable concentration of iodine-131 to produce a 5 mrem/year dose to the thyroid of the 1-year-old child based on the iodine concentration and compares this to the recommendation of FRC.

For iodine-131, it is suggested that the ratio of iodine-131 to iodine be used to predict yearly man-rem dose to the thyroids of infants when the concentration of iodine in the milk samples

[2] FRC rounded off 74 to 80 and for action guides rounded it off to 100 (see Burnett (*16*)).

Table 3. Allowable concentration of iodine-131 versus concentration of iodine

(For 5 mrem/yr to infant thyroid and C = 350 μg/g)

Actual iodine (μg/liter)	Allowable iodine-131 [a] (pCi/liter)	Recommendation of FRC [b] iodine-131 (pCi/liter)
70	0.8	0.8
100	1.2	.8
200	2.4	.8
500	6.0	.8

[a] $T_b = 20$ d; m = 2 g; $\xi = 0.22$ MeV.
[b] $T_b = 138$ d; m = 2 g; $\xi = 0.22$ MeV.

consistently exceeds 70 μg/liter, and, below this value, use the present method of dose assessment. Since iodine-127 in cow's milk decreases when the cows return to pasture and may consistently be less than 70 μg/liter, there will not be as much use of the ratio for iodine-131 dose determination as for iodine-129.

Conclusions and recommendations

In order to use specific activity of iodine isotopes in milk to calculate thyroid doses to members of the general public, it will be necessary to establish a range of iodine concentrations in the thyroid based on age groups or a relationship between iodine intake and iodine thyroid concentration which may also be a function of age.

Specific activity for radioiodines in milk should not be used for design or control of nuclear facilities. The degree of radioiodine removal should not be dependent on differences in dairy farming practices. Use of compounds such as EDDI could drastically change iodine concentrations in milk.

A study of stable iodine concentrations in milk in various parts of the country and in different seasons is recommended to determine the ranges of stable iodine and possible reasons for fluctuations. This will be important in determining aggregate man-rem thyroid doses.

In calculating actual yearly man-rem thyroid doses to the general public from drinking of milk, more realistic doses can be determined from specific activity when there is an excess of iodine in the milk. If a concentration of 350 μg of iodine per gram of thyroid tissue is used, then the dose can be determined as follows:

Use 440 times the ratio of iodine-129 to iodine in pCi/μg to calculate yearly mrem thyroid dose when iodine in milk consistently exceeds 10 μg/liter.

Use 410 times the ratio of iodine-131 to iodine in pCi/μg to calculate yearly thyroid dose to an infant when iodine in milk consistently exceeds 70 μg/liter. This is based on a 20 day biological half-life.

If the concentration of iodine in the thyroid "C" is equal to 1000 μg/g, then the above doses should be multiplied by a factor of 2.9.

Specific activity should not be used to determine the dose from a short term ingestion of iodine-131 such as might occur in an emergency situation unless there is a good history of iodine levels in the local milk supplies to support use of specific activity. The feeding of increased amounts of iodine compounds normally being fed to cows to decrease dose to the thyroid is a possible emergency countermeasure that should be investigated further.

Acknowledgments

REFERENCES

(1) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Report of ICRP Committee II on permissible dose for internal radiation, ICRP Publication 2. Pergamon Press, Ltd., Oxford, London (1959).
(2) BRYANT, P. M. Derivation of working limits for continuous release rates of ¹³¹I to atmosphere. Health Phys 19:611 (1970).
(3) RUSSELL, J. L. and P. B. HAHN. Public health aspects of iodine-129 from the nuclear power industry. Radiol Health Data Rep 12:189–194 (April 1971).
(4) TADMOR, J. Consideration of stable iodine in the environment in the evaluation of maximum permissible concentrations for iodine-129. Radiol Health Data Rep 12:611–614 (December 1971).

(5) STATE OF NEW YORK DEPARTMENT OF ENVIRONMENTAL CONSERVATION. 1971 annual report of environmental radiation in New York (July 1972).

(6) STATE OF NEW YORK DEPARTMENT OF ENVIRONMENTAL CONSERVATION. Annual report of environmental radiation in New York State, 1972 (September 1973).

(7) COCHRAN, J. A., D. G. SMITH, P. J. MAGNO and B. SCHLEIEN. An investigation of airborne radioactive effluent from an operating nuclear fuel reprocessing plant, BRH/NERL 70–3. Northeastern Radiological Health Laboratory, Winchester, Mass. 01890 (July 1970).

(8) MAGNO, P. J., T. C. REAVEY and J. C. APIDIANAKIS. Iodine-129 in the environment around a nuclear fuel reprocessing plant, ORP/SID 72–5. Environmental Protection Agency, Washington, D.C. 20460 (July 1970).

(9) KELLEHER, W. J. and E. J. MICHAEL. Iodine-129 in milk. Presented at 1973 Annual Health Physics Society Meeting in Miami Beach (June 1973).

(10) ATOMIC ENERGY COMMISSION. AEC Regulatory Guide 1.42, Interim licensing policy on as low as practicable for gaseous radioiodine releases from light-water-cooled nuclear power reactors (June 1973).

(11) ATOMIC ENERGY COMMISSION. Regulatory Guide 4.3, Measurements of radionuclides in the environment: analysis of iodine-131 in milk (September 1973).

(12) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

(13) MATUSZEK, J. M., J. C. DALY, S. GOODYEAR, C. J. PAPERIELLO and J. J. GABAY. Environmental levels of iodine-129, IAEA/SM–180/39. International Atomic Energy Agency, Symposium on Environmental Surveillance around Nuclear Installations, Warsaw, Poland (November 1973).

(14) LE BLANC, A. D., R. L. BELL and P. C JOHNSON. Measurement of iodine-127 concentration in thyroid tissue by x-ray fluorescence. J Nucl Med 14:816–819 (1973).

(15) SOLDAT, J. K., J. F. CLINE, B. KLEPPER, B. E. VAUGHAN, F. P. BRAUER, J. E. FAGER, W. H. RICKARD and D. G. WATSON. The radioecology of iodine-129, an interim report, BNWL–1783. Battelle Pacific Northwest Laboratories (September 1973).

(16) BURNETT, T. J. A derivation of the "factor of 700" for iodine-131. Health Phys 18:73–74 (1970).

SECTION I. MILK AND FOOD

Milk Surveillance, April 1974

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 65 sampling stations: 63 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations.

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling tions.

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (1). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (2) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of
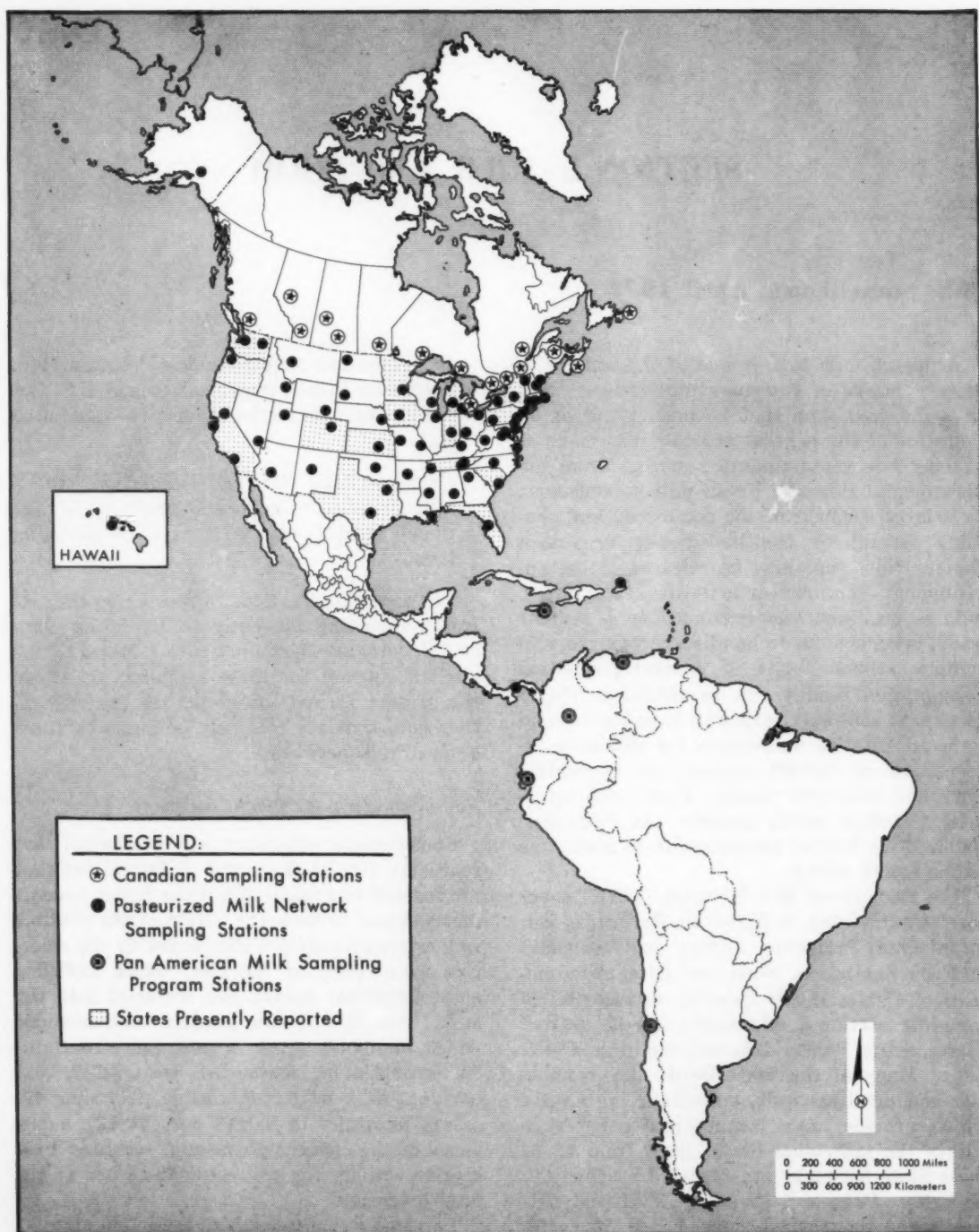
Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, first it was necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Research and Development Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the network reports in *Radiation Data and Reports,* 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The fre-

Table 1.   Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131: (96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137: (53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89: (29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90: (32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

quency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (6) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (6). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (3). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error of precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (3). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter;
	5–10% for levels ≧50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter;
	4–10% for levels ≧20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≧100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports*.

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are reported routinely in *Radiation Data and Reports*. The relationship between the PMN

Table 2. Concentrations of radionuclides in milk for April 1974 and 12-month period, May 1973 through April 1974

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:					
Ala: Montgomery [c]	P	NA	3	12	3
Alaska: Palmer [c]	P	NA	4	13	2
Ariz: Phoenix [c]	P	NA	0	0	0
Ark: Little Rock [c]	P	NA	12	11	1
Calif: Los Angeles [c]	P	NA	0	0	0
Sacramento [c]	P	NA	0	0	1
San Francisco [c]	P	NA	0	0	0
Del Norte	P	NA		NA	
Fresno	P	NA		NA	
Humboldt	P	NA		NA	
Los Angeles	P	NA		NA	
Mendocino	P	NA		NA	
Sacramento	P	NA		NA	
San Diego	P	NA		NA	
Santa Clara	P	NA		NA	
Shasta	P	NA		NA	
Sonoma	P	NA		NA	
Colo: Denver [c]	P	NA	3	0	0
East	R	NA	NA	NS	23
Northeast	R	NS	NA	NS	0
Northwest	R	NS	NA	NS	4
South Central	R	NS	NS	NS	NS
Southeast	R	NS	NA	NS	0
Southwest	R	NA	NA	0	0
West	R	NS	NA	NS	0
Conn: Hartford [c]	P	NA	4	0	2
Central	P	NA		NA	
Del: Wilmington [c]	P	NA	8	0	1
D.C: Washington [c]	P	NA	4	0	0
Fla: Tampa [c]	P	NA	4	32	25
Central	R	5	5	15	28
North	R	4	6	0	12
Northeast	R	4	6	16	26
Southeast	R	5	5	28	48
Tampa Bay area	P	4	4	20	25
West	R	7	8	16	10
Ga: Atlanta [c]	P	NA	4	0	1
Hawaii: Honolulu [c]	P	NA	4	0	0
Idaho: Idaho Falls [c]	P	NA	4	0	0
Ill: Chicago [c]	P	NA	5	0	0
Ind: Indianapolis [c]	P	NA	5	0	3
Central	P	5	5	0	4
Northeast	P	6	5	0	10
Northwest	P	5	7	0	7
Southeast	P	6	6	0	6
Southwest	P	7	7	0	5
Iowa: Des Moines [c]	P	NA	4	0	5
Des Moines	P	4	5	0 (4)	0
Iowa City	P	5	5	0	0
LeMars	P	4	4	0	0
Little Cedar	P	8	6	0	0
Kans: Wichita [c]	P	NA	6	0	1
Coffeyville	P	6	6	0	7
Dodge City	P	6	5	0	7
Falls City, Nebr	R	NS	5	NS	8
Hays	P	4	6	0	5
Kansas City	P	6	4	0	5
Topeka	P	4	6	0	6
Wichita	P	4	6	0	7
Ky: Louisville [c]	P	NA	5	0	1
La: New Orleans [c]	P	NA	5	0	2
Maine: Portland [c]	P	NA	8	12	12
Md: Baltimore [c]	P	NA	8	0	2
Mass: Boston [c]	P	NA	8	0	7
Mich: Detroit [c]	P	NA	6	0	3
Grand Rapids [c]	P	NA	7	0	1
Bay City	P	8	11	0	2
Charlevoix	P	9	9	0	2
Detroit	P	19	9	0	0
Grand Rapids	P	12	13	0	5
Lansing	P	5	11	0	3
Marquette	P	11	12	7	6
Monroe	P	9	13	0	1
South Haven	P	11	14	0	2
Minn: Minneapolis [c]	P	NA	7	0	1
Bemidji	P	NS	7	NS	0
Duluth	P	12	17	12	16
Fergus Falls	P	6	7	0	0
Little Falls	P	12	16	0	0
Mankato	P	5	5	0	0
Marshall	P	NS	3	NS	0

See footnotes at end of table.

Sampling location		Type of sample [a]	Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
Minn:	Minneapolis	P	8	9	0	0
	Rochester	P	6	6	0	0
Miss:	Jackson [c]	P	NA	8	0	4
Mo:	Kansas City [c]	P	NA	4	0	0
	St. Louis [c]	P	NA	8	0	1
Mont:	Helena [c]	P	NA	0	0	0
Nebr:	Omaha [c]	P	NA	0	0	0
Nev:	Las Vegas [c]	P	NA	8	0	0
N.H:	Manchester [c]	P	NA	9	0	5
N.J:	Trenton [c]	P	NA	4	0	1
N. Mex:	Albuquerque [c]	P	NA	0	0	0
N.Y:	Buffalo [c]	P	NA	5	0	1
	New York City [c]	P	NA	4	0	2
	Syracuse [c]	P	NA	6	0	1
	Albany	P	NA	4	0	0
	Buffalo	P	NA	4	0	0
	Messena	P	NA	7	11	10
	New York City	P	NA	7	0	0
	Syracuse	P	NS	4	NS	0
N.C:	Charlotte [c]	P	NA	9	0	4
N. Dak:	Minot [c]	P	NA	6	0	0
Ohio:	Cincinnati [c]	P	NA	6	0	3
	Cleveland [c]	P	NA	7	0	2
Okla:	Oklahoma City [c]	P	NA	2	0	0
Oreg:	Portland [c]	P	NA	5	0	1
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia [c]	P	NA	5	11	2
	Pittsburgh [c]	P	NA	10	0	2
	Dauphin	P	6	5	0	0
	Erie	P	7	7	0	0
	Philadelphia	P	6	5	0	0
	Pittsburgh	P	6	5	0	0
R.I:	Providence [c]	P	NA	4	14	4
S.C:	Charleston [c]	P	NA	5	13	8
	Anderson-01	R	NS	5	NS	0
	Anderson-02	R	NS	5	NS	0
	Chapin	R	7	7	8	7
	Clemson	R	NS	8	NS	8
	Columbia	R	7	6	16	10
	Fairfield	R	6	6	6	10
	Hartsville-02	R	NS	6	NS	9
	Hartsville-03	R	NS	13	NS	13
	Lee County	R	NS	7	NS	8
	Oconee County	R	NS	7	NS	5
	Pickens	R	NS	7	NS	9
	Williston	R	NS	7	NS	15
	Winnsboro	R	6	6	22	16
	York-01	R	NS	5	NS	6
	York-02	R	NS	5	NS	1
S. Dak:	Rapid City [c]	P	NA	8	0	1
Tenn:	Chattanooga [c]	P	NA	6	15	2
	Knoxville [c]	P	NA	0	15	2
	Memphis [c]	P	NA	6	0	5
	Chattanooga	R	NA	7	0	5
	Clinton	R	NA	7	0	4
	Fayetteville	R	NA	8	0	3
	Kingston	R	NA	6	0	4
	Knoxville	P	NA	6	0	0
	Lawrenceburg	P	NA	5	0	4
	Nashville	R	NA	6	0	3
	Pulaski	R	NA	9	0	6
	Sequoyah	P	NS	0	NS	0
Tex:	Austin [c]	P	NA	3	0	0
	Dallas [c]	P	NA	3	0	0
Utah:	Salt Lake City [c]	P	NA	2	0	0
Vt:	Burlington [c]	P	NA	5	0	4
Va:	Norfolk [c]	P	NA	6	0	1
Wash:	Seattle [c]	P	NA	4	0	0
	Spokane [c]	P	NA	4	0	0
	Benton County	R	NS	1	NS	0
	Franklin County	R	3	5	0	0
	Longview	R	8	5	0	7
	Sandpoint, Idaho	R	4	5	0	1
	Skagit County	R	1	4	0	0
W. Va:	Charleston [c]	P	NA	8	0	2
Wisc:	Milwaukee [c]	P	NA	3	0	1
Wyo:	Laramie [c]	P	NA	0	0	1

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for April 1974 and 12-month period, May 1973 through April 1974—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:					
Alberta: Calgary	P	NA		2	6
Edmonton	P	NA		6	9
British Columbia:					
Vancouver	P	NA		4	11
Manitoba: Winnipeg	P	NA		7	9
New Brunswick:					
Moncton	P	NA		4	9
Newfoundland:					
St. John's	P	NA		8	13
Nova Scotia:					
Halifax	P	NA		2	8
Ontario: Ottawa	P	NA		3	6
Sault Ste. Marie	P	NA		4	13
Thunder Bay	P	NA		13	9
Toronto	P	NA		2	5
Windsor	P	NA		5	5
Quebec: Montreal	P	NA		4	5
Quebec	P	NA		3	11
Saskatchewan:					
Regina	P	NA		1	5
Saskatoon	P	NA		2	6
CENTRAL AND SOUTH AMERICA:					
Canal Zone:					
Cristobal [c]	P	NS	0	NS	0
Chile: Santiago	P	0	0	11	1
Colombia: Bogota	P	0	1	0	0
Ecuador: Guayaquil	P	0	1	0	0
Jamaica: Kingston	P	NS	4	NS	24
Puerto Rico:					
San Juan [c]	P	NA	3	0	2
Venezuela: Caracus	P	0	0	0	1
PMN network average [d]		5	5	2	2

[a] P, pasteurized milk,
R, raw milk.
[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.
[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.
[d] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.
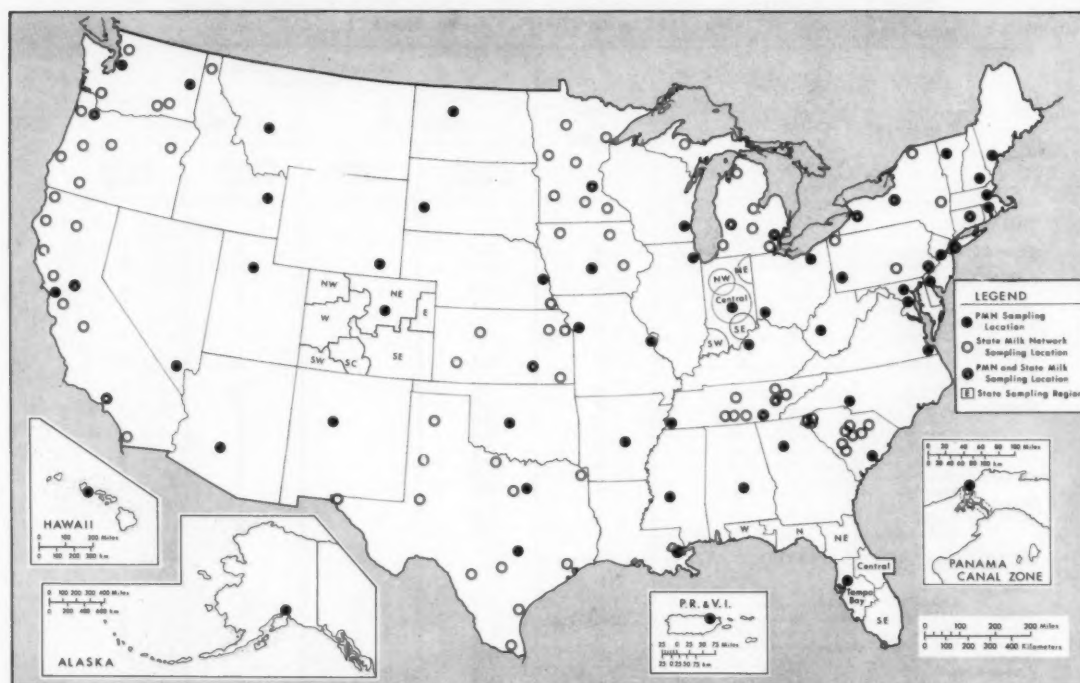
Figure 2. State and PMN milk sampling stations in the United States

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for April 1974 and the 12-month period, May 1973 to April 1974. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at all of the stations for April 1974 were below the respective practical reporting levels. The following station average reflects a sample in which barium-140 was detected: Kans: Hays (State), 10 pCi/liter.

Strontium-90 monthly averages ranged from 0 to 19 pCi/liter in the United States for April 1974 and the highest 12-month average was 17 pCi/liter (Duluth, Minn.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 32 pCi/liter in the United States for April 1974, and the highest 12-month

average was 48 pCi/liter (Southeast Florida) representing 1.3 percent of the value derived from the recommendations given in the Federal Radiation Council report. Table 3 gives the

Table 3. Strontium-89 and strontium-90 results of PMN milk samples composited by region

EPA region	States located in region	Strontium-90[a] concentration (pCi/liter)
I	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	5
II	New Jersey, New York, Puerto Rico	4
III	Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia	6
IV	Alabama, Canal Zone, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee	7
V	Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin	6
VI	Arkansas, Louisiana, New Mexico, Oklahoma, Texas	6
VII	Iowa, Kansas, Missouri, Nebraska	6
VIII	Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming	4
IX	Arizona, California, Hawaii, Nevada	0
X	Alaska, Idaho, Oregon, Washington	4

[a] All strontium-89 results were less than the practical reporting level (5 pCi/liter).

strontium-89 and strontium-90 results of PMN milk samples composited by region.

The Office of Radiation Programs is in the process of modifying the milk program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

REFERENCES

(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER, and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

(2) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(5) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, June 1972, Technical experiment 72 MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

(6) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).
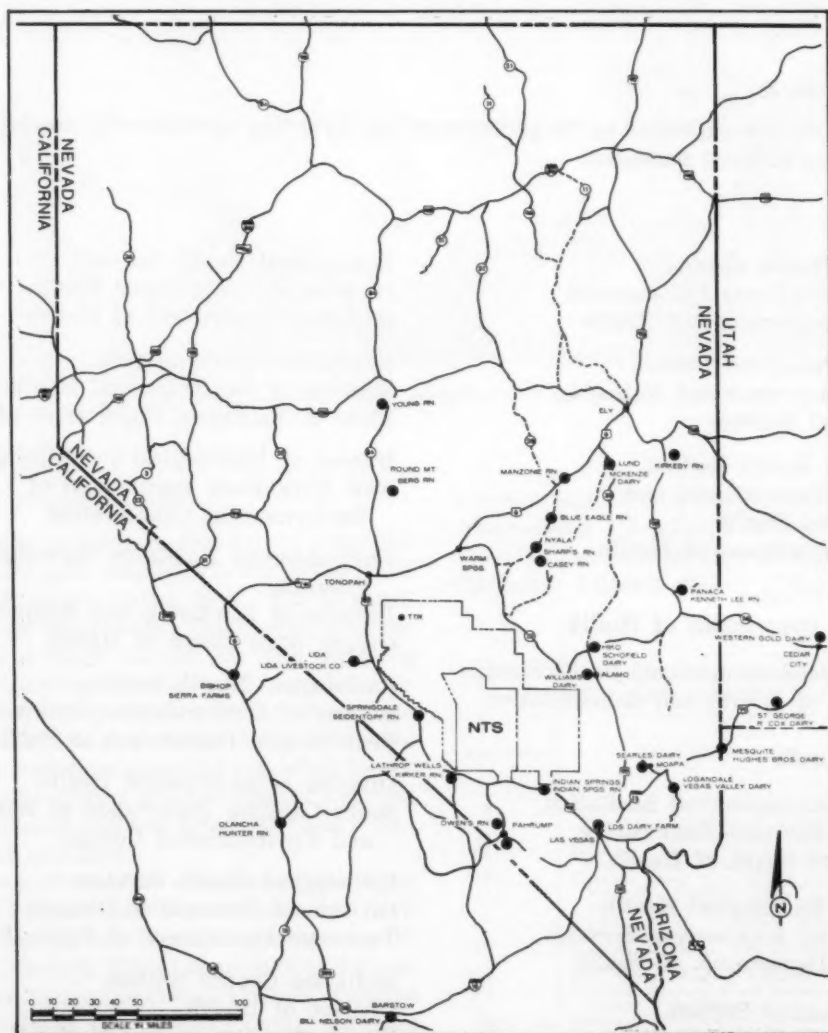
Figure 1. NERC-LV Milk Surveillance Network

Milk Surveillance Network, Second Quarter 1974

National Environmental Research Center—
Las Vegas
Environmental Protection Agency

The Milk Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV) consists of 24 routine and 1 alternate sampling location (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS).

[1] The Milk Surveillance Network is operated under a Memorandum of Understanding (No. AT(26-1)–539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

Table 1. Milk surveillance results, April-June 1974

Location	Date collected (1974)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
			Cesium-137	Strontium-89	Strontium-90	Tritium
California:						
Bishop:						
Sierra Creamery	4/ 3	11	<10	<1.5	2.2±0.87	NA
Hinkley:						
Bill Nelson Dairy	4/ 2	12	<10	<1.4	1.4±1.1	NA
Olancha:						
Hunter Ranch	4/ 2	13	<10	<1.3	<1.0	NA
Nevada:						
Alamo:						
Williams Dairy	4/ 9	12	<10	<1.6	1.9±1.2	NA
Austin:						
Young's Ranch	4/ 2	13	<10	<1.4	2.2±1.1	770±220
Currant:						
Blue Eagle Ranch	4/ 9	13	<10	<1.4	1.0± .85	NA
Manzonie Ranch	4/ 9	13	<10	<1.2	<1.0	NA
Hiko:						
Schofield Dairy	4/ 8	12	<10	<1.5	1.6±1.2	420±210
Indian Springs:						
Indian Springs Ranch	NS					
Las Vegas:						
LDS Dairy Farms	4/ 5	12	<10	<1.1	1.1± .89	350±220
Lathrop Wells:						
Kirker Ranch	4/11	13	<10	<1.3	1.5± .82	NA
Lida:						
Lida Livestock Company	4/ 1	13	<10	<1.6	<1.1	NA
Logandale:						
Vegas Valley Dairy	4/ 1	12	<10	<1.8	<1.2	NA
Lund:						
McKenzie Dairy	4/ 9	12	<10	<1.3	1.5±1.1	790±220
Mesquite:						
Hughes Bros. Dairy	4/ 1	12	<10	<1.3	2.6±1.1	240±220
Moapa:						
Searles Dairy	4/ 1	12	<10	<1.4	2.8±1.1	NA
Nyala:						
Sharp's Ranch	4/ 4	13	[c] <100	<1.6	2.9± .99	<210
Pahrump:						
Burson Ranch	4/12	13	<10	<1.3	1.5±1.0	NA
Panaca:						
Kenneth Lee Ranch	4/10	13	<10	<1.2	1.1± .96	NA
Round Mountain:						
Berg Ranch	4/ 2	13	<10	<1.8	4.5±1.4	NA
Shoshone:						
Kirkeby Ranch	4/ 8	13	<10	<2.0	<1.2	NA
Springdale:						
Seidentopf Ranch	4/10	13	<10	<1.6	1.3±1.2	NA
Utah:						
Cedar City:						
Western Gold Dairy	4/ 2	12	<10	<1.2	1.4± .96	NA
St. George:						
R. Cox Dairy	4/ 1	12	<10	<1.3	<.96	NA

[a] 11—Pasteurized milk.
  12—Raw milk from Grade A producer(s).
  13—Raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size increased minimum detectable activity.
NA, no analysis.
NS, no sample.

In the event of a release of radioactivity from the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations. Additional milk sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the July 1973 issue of *Radiation Data and Reports*.

Results

The analytical results of all milk samples collected in the second quarter of 1974 by NERC-LV are listed in table 1. With the exception of cesium-137 at levels near the minimum detectable concentration (MDC) of 10 pCi/liter, no gamma-emitting fission products were identified by gamma spectrometry in any of the samples collected in the second quarter. Levels of tritium near the MDC for this radionuclide ($\sim$200 pCi/liter) were also measured by liquid scintillation counting techniques. The highest concentration of tritium during the second quarter was 790 $\pm$ 220 pCi/liter. The levels of cesium-137 and tritium measured in the milk were attributed to worldwide fallout.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet	July 1971–December 1972	February 1974
Carbon-14 in Total Diet and Milk	1972–1973	November 1973
Strontium-90 in Tri-City Diets	1972	December 1973

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (1). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2–4) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	1971 and 1972	November 1973
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
ERAMS Surface Water and Drinking Water Components	January–March 1974	August 1974
Florida	1970	April 1974
Interstate Carrier Drinking Water	1971	May 1972
Kansas	1972	August 1974
Minnesota	July 1971–June 1972	March 1974
New York	January–December 1972	June 1974
North Carolina	1971	July 1974
Radiostrontium in Tap Water, HASL	January–December 1972	December 1973
Washington	July 1970–June 1971	August 1973

REFERENCES

(1) U.S. PUBLIC HEALTH SERVICE. Drinking water standards. revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(2) FEDERAL RADIATION COUNCIL. Radiation Guidance Protection for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(3) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Water Surveillance Network, Second Quarter 1974

National Environmental Research Center—
Las Vegas
Environmental Protection Agency

The Water Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 59 sampling locations (figures 1 and 2) in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing conducted by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

In the event of a release of radioactivity from the NTS, special sampling within the affected

[1] The Water Surveillance Network is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.
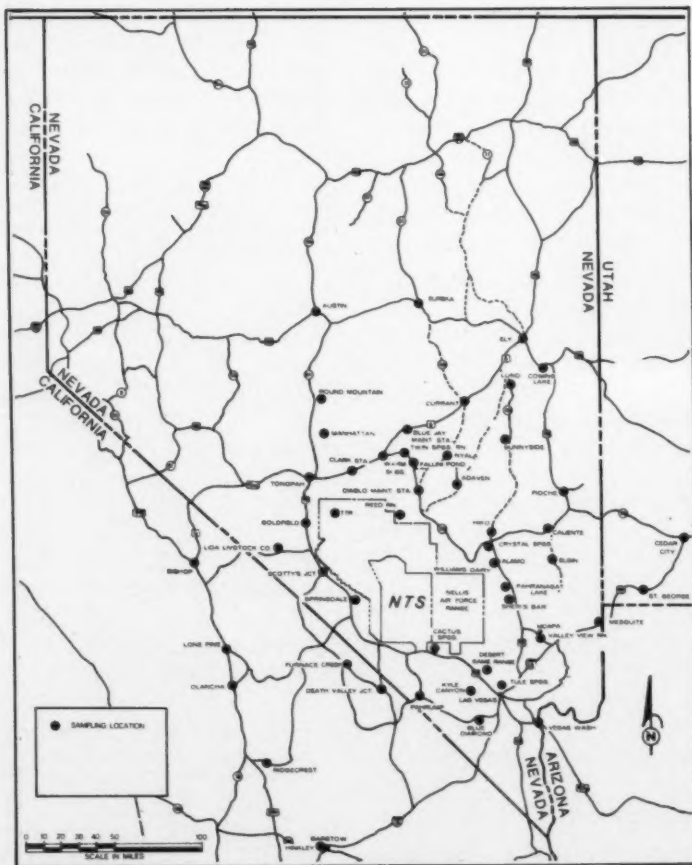
Figure 1. NERC-LV Water Surveillance Network
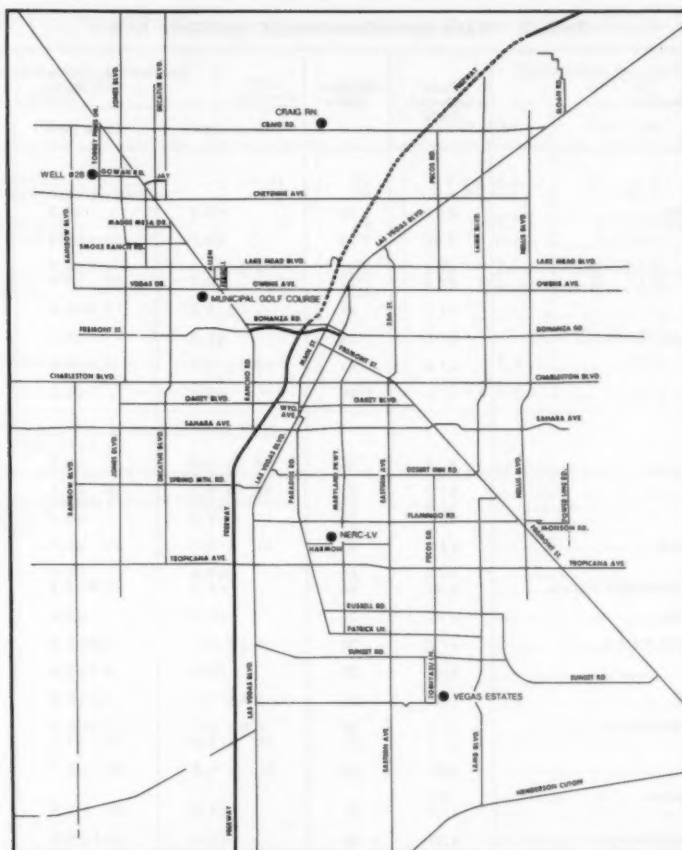
Figure 2. NERC-LV Water Surveillance Network—Las Vegas Valley

area is conducted to determine radionuclide concentrations. Additional water sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the water results reported in the July 1973 issue of *Radiation Data and Reports*.

Results

The routine analytical results of all water samples collected in the second quarter of 1974 by the NERC-LV are listed in table 1. No gamma-emitting fission products were identified by gamma spectrometry in any of the second quarter samples.

Table 1. Water surveillance results, April-June 1974

Location	Date collected (1974)	Sample type [a]	Radionuclide concentrations [b] (pCi /liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	4/ 3	23	<1.4	<3.2	NA
Death Valley Junction:					
Lila's Cafe	4/10	23	<4.2	10 ±3.8	<210
Furnace Creek:					
Pond	4/ 4	21	6.4± 5.1	8.8±3.7	NA
Visitor's Center	4/ 4	27	<3.7	12 ±3.8	NA
Hinkley:					
Bill Nelson Dairy	4/ 2	23	7.8± 5.2	4.8±3.4	NA
Lone Pine:					
Forest Service Ranger Station	4/ 2	24	<1.8	<3.2	NA
Olancha:					
Haiwee Reservoir	4/ 2	21	9.8± 4.7	5.9±3.4	NA
Ridgecrest:					
City Hall	4/ 2	23	<3.0	<3.3	NA
Nevada:					
Adaven:					
Canfield Ranch	4/ 2	22	3.7± 2.9	<3.2	NA
Alamo:					
Pahranagat Lake	4/ 8	21	16 ± 7.1	18 ±4.1	NA
Sheri's Bar	4/ 8	23	<2.9	4.0±3.1	NA
Williams Dairy	4/ 8	23	<3.9	<3.1	NA
Austin:					
Nevada National Bank	4/ 3	27	21 ± 5.7	13 ±3.8	NA
Blue Diamond:					
Post Office	4/ 9	23	<3.3	<3.1	<210
Blue Jay Highway Maintenance Station	4/11	23	<2.5	6.6±3.3	NA
Cactus Springs:					
Mobil Service Station	4/12	27	<2.3	<3.1	<210
Caliente:					
Agricultural Extension Station	4/ 8	23	5.1± 3.4	4.9±3.2	NA
Clark Station:					
Five Mile Ranch	4/11	27	<3.0	8.1±3.4	NA
Currant:					
Currant Ranch Cafe	4/10	27	9.6± 5.2	5.3±3.2	NA
Diablo:					
Highway Maintenance Station	4/ 2	23	4.7± 3.5	5.0±3.3	NA
Reed Ranch	4/ 1	21	12 ± 5.6	18 ±4.1	NA
Elgin:					
Water tower	4/10	23	11 ± 5.6	10 ±3.7	NA
Ely:					
Chevron Service Station	NS				
Comins Lake	4/ 8	21	<2.8	15 ±3.8	NA
Eureka:					
Highway Maintenance Station	4/10	24	<3.4	5.8±3.2	NA
Goldfield:					
Chevron Service Station	4/ 4	23	<2.3	<3.2	NA
Hiko:					
Crystal Springs	4/ 8	27	<3.2	9.2±3.4	NA
Schofield Dairy	4/ 8	23	24 ± 8.3	33 ±4.8	NA
Las Vegas:					
Craig Ranch Golf Course	4/ 5	23	7.0± 3.8	6.6±3.4	290±220
Desert Game Range	4/12	23	<2.2	<3.1	<210
Lab I NERC	4/ 5	24	<3.0	<3.1	1 000±230
Lake Mead Vegas Wash	4/ 5	21	7.0± 5.2	6.7±3.5	940±230
Las Vegas Water District Well 28	4/ 5	23	3.4± 2.7	<3.2	<210
Municipal Golf Course	4/ 5	23	<1.9	<3.2	<210
Tule Springs	4/15	23	6.6± 3.4	3.3±3.1	<210
Tule Springs Pond	4/15	21	5.1± 3.2	3.4±3.1	NA
Vegas Estates	4/05	23	7.9± 5.4	14 ±4.0	<210
Lida:					
Lida Livestock Company	4/ 1	27	4.6± 3.6	<3.2	NA
Pond at storage tank	4/ 1	21	<2.8	<3.2	NA
Lund:					
Gardner Grocery	4/ 9	23	<2.9	4.0±3.1	NA
Manhattan:					
Country store	4/ 3	23	9.8± 4.9	5.4±3.4	NA
Mesquite:					
Hughes Bros. Dairy	4/ 1	23	6.2± 4.7	4.0±3.3	NA
Moapa:					
Pedersen Valley View Ranch	4/ 1	27	<4.4	11 ±3.8	NA
Mt. Charleston:					
Kyle Canyon Fire Station	4/12	27	<2.1	<3.1	330±210
Nyala:					
Sharp's Ranch	4/ 4	23	3.5± 2.8	<3.2	NA
Pahrump:					
Texaco Service Station	4/ 9	23	3.5± 2.8	4.5±3.2	NA
Pioche:					
County courthouse	4/10	24	<2.2	6.3±3.3	NA
Round Mountain:					
Mobil Service Station	4/ 3	27	4.5± 3.0	<3.2	NA
Scotty's Junction:					
Holloway Ranch	4/ 1	23	6.3± 4.7	9.5±3.7	<260
Springdale:					
Pond	4/10	21	<3.9	10 ±3.7	NA

See footnotes at end of table.

Table. 1   Water surveillance results, April-June 1974—continued

Location	Date collected (1973)	Sample type [a]	Radionuclide concentrations [b] (pCi /liter)		
			Gross alpha	Gross beta	Tritium
Sunnyside:					
Adam McGill Reservoir	4/11	21	4.9± 4.2	12 ±3.7	NA
Wildlife Management Headquarters	4/11	27	4.8± 3.2	<3.0	NA
Tonopah:					
Jerry's Chevron Station	4/ 4	23	<2.7	4.7±3.3	NA
Tonopah Test Range CP-1	4/ 4	23	7.3± 4.4	4.8±3.3	NA
Warm Springs:					
Fallini's Pond	4/ 3	21	21 ± 9.1	49 ±5.8	NA
Service Station and Cafe	4/11	27	30 ±10	31 ±4.8	NA
Twin Springs Ranch	4/ 3	23	<3.2	10 ±3.7	NA
Utah:					
Cedar City:					
M. D. Baldwin residence	4/ 2	24	<1.3	<3.2	NA
St. George:					
R. Cox Dairy	4/ 1	24	3.4± 2.4	<3.2	NA

[a] 21—Pond, lake, reservoir, stock tank, stock pond.
  22—Stream, river, creek.
  23—Well.
  24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water such as well and spring).
  27—Spring.
[b] Two-sigma counting error provided when available.
  NA, not analyzed.
  NS, no sample.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radio-analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of pro-grams are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from actvities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were covered previously in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and Other Areas	1972	August 1974
Krypton-85 in air	July 1970–1972	March 1974
Mexican air monitoring program	July–December 1973	May 1974
Plutonium in airborne particulates	April–June 1973	June 1974

1. ERAMS Gross Radioactivity and Deposition Component April 1974

Office of Radiation Programs
Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS), which began in July 1973, was developed from previously operating radiation monitoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

The ERAMS Gross Radioactivity and Deposition Component is a restructuring of the previous Radiation Alert Network (RAN). Sampling stations were relocated (figure 1) to more closely monitor the potential sources of environmental radioactivity and to provide the means for obtaining the maximum population coverage. The component consists of 74 sampling stations, 55 of which are on standby status and can be activated when the need arises. The remaining 19 stations collect air particulates continuously with the filters being changed one or two times per week. Most of the stations are operated by State or local health department personnel.

The station operators perform gross beta radioactivity "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples and precipitation samples, which are collected concurrently with the 19 air sampling stations, are sent to the Eastern Environmental Radiation Facility for laboratory gross beta radioactivity analyses. All field estimate results are reported to the appropriate Environmental Protection Agency officials by mail or telephone depending on the levels found. A compilation of the daily
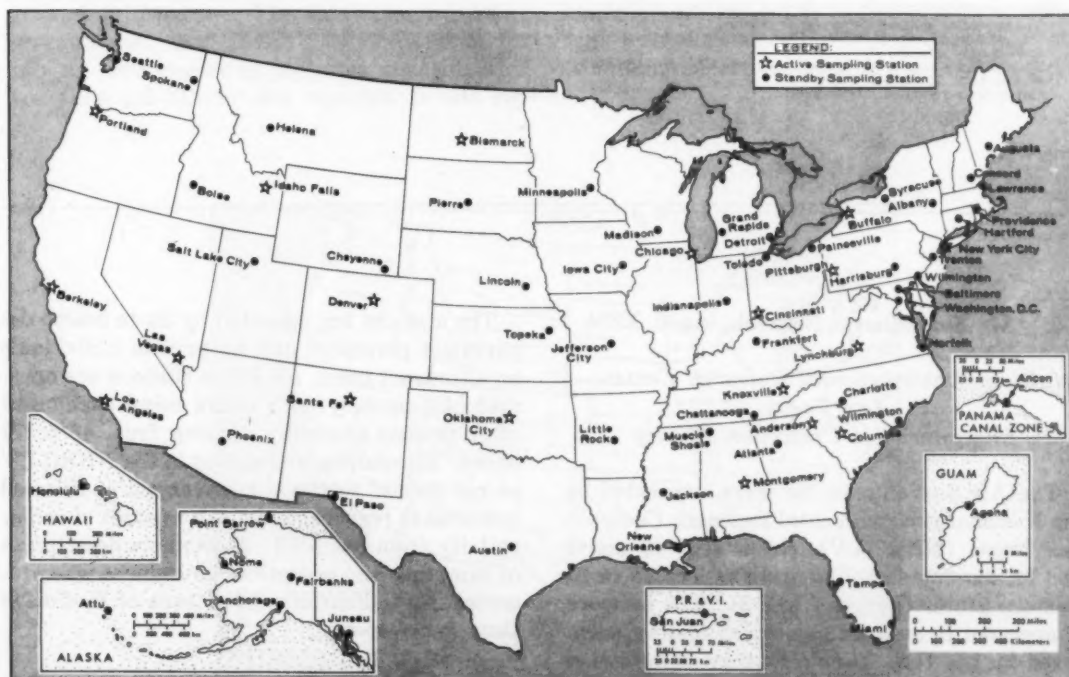

Figure 1. ERAMS Gross Radioactivity and Deposition Component sampling locations

measurements is available upon request from the Eastern Environmental Radiation Facility, Montgomery, Ala. 36109.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during April 1974.

Table 1. Gross beta radioactivity in surface air and precipitation, April 1974

Station location [a]	Number of samples	Gross beta radioactivity (pCi/m³)						Precipitation	
		5-hour field estimate			Laboratory measurement			Laboratory estimate of deposition	
		Maximum	Minimum	Average[b]	Maximum	Minimum	Average[b]	Depth (mm)	Total deposition (nCi/m²)
Ala: Montgomery	9	1	0	1	0.47	0.10	0.24	79	1.08
Calif: Berkeley	9	0	0	0	.26	.07	.11	27	.09
Los Angeles	9	1	0	1	.31	.03	.17		
Colo: Denver	9	2	1	1	.52	.11	.32	32	1.00
Idaho: Idaho Falls	9				.39	.09	.20	22	.51
Ill: Chicago	(e)								
Ind: Indianapolis [d]	7	0	0	0	.24	.09	.17		
Nev: Las Vegas	9	1	1	1	.38	.20	.29		
N. Mex: Santa Fe	5	1	0	0	.42	.14	.30		
N.Y.: Buffalo	9	1	0	0	.33	.05	.15	13	.42
New York City	(e)								
N. Dak: Bismarck	8	2	0	1	.28	.07	.15	52	1.16
Ohio: Columbus [e]	8	2	0	1	.35	<.01	.20		
Okla: Oklahoma City	0								
Oreg: Portland	22	1	0	0	.57	.03	.12		
Pa: Harrisburg [f]	20	1	0	1	.28	.03	.14		
S.C: Anderson	(e)								
Columbia	8	1	0	0	.40	.06	.23	84	2.46
Tenn: Knoxville	(e)								
Va: Lynchburg	(e)								
Network summary	141	2	0	1	0.57	<0.01	0.20	44	0.96

[a] The remaining stations are on standby status.
[b] The monthly average is calculated by weighting the estimates of individual air samples with length of sampling period.
[e] Station to be established.
[d] Standby station operated continuously at the request of the State.
[e] Station to be relocated to Cincinnati.
[f] Station to be relocated to Pittsburgh.

2. Air Surveillance Network, April 1974

National Environmental Research Center— Las Vegas Environmental Protection Agency

The Air Surveillance Network,[1] operated by the National Environmental Research Center— Las Vegas (NERC-LV), consists of 49 active and 72 standby sampling stations located in 21 western States (figures 2 and 3). The network is operated in support of nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged after periods generally ranging from 48 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports*.
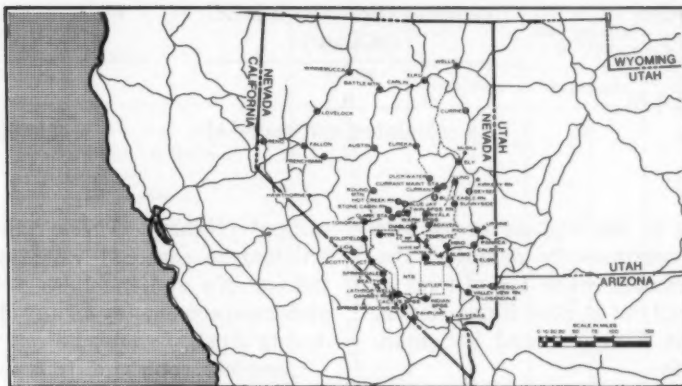
Figure 2. NERC-LV Air Surveillance Network stations in Nevada

Table 2 presents the average gross beta concentrations in air for each of the active network stations and for all standby stations, which were activated on April 1 for 1 week of operation to check equipment and gather background information. The minimum reporting concentration for gross beta activity is 0.1 pCi/m³ . For reporting purposes, concentration less than 1.0 pCi/m³ are reported to one significant figure, and those equal to or greater than 1.0 pCi/m³ are reported to two significant figures. For averaging purposes, individual concentration values less than the minimum detectable concentration (—0.03 pCi/m³ for a 700 m³ sample) are set equal to the minimum detectable concentration (MDC). Reporting and rounding-off conventions are as follows:

Figure 3. NERC-LV Air Surveillance Network stations outside Nevada

Concentration (pCi/m³)		Reported value of concentration above MDC (pCi/m³)	Reported value of concentration below MDC (pCi/m³)
<0.05		<0.1	<0.1
≥0.05	<0.15	0.1	<0.1
≥0.15		As calculated and rounded	<calculated MDC

As shown by table 2, the highest gross beta concentrations at continuously operated stations within the network were 1.8 pCi/m³ at Milford, Utah, 1.3 pCi/m³ at Blue Eagle Ranch, Nev., 1.2 pCi/m³ at Kingman and Seligman, Ariz., and Nyala, Nev.

From gamma spectrometry results, fission products in varying combinations of zirconium-95, ruthenium-103, and cerium-141 were identified on filters collected throughout the network. The highest concentrations of these radionuclides, respectively, were 0.56 pCi/m³ (Nyala), 0.14 pCi/m³ (Shoshone), and 0.14 pCi/m³ (Nyala). These radionuclides are attributed to seasonal variations in worldwide fallout. No radionuclides were identified by gamma spectrometry on any charcoal cartridges during April.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA Regional Offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 1.   Summary of gross beta radioactivity concentration in air, April 1974

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	13	1.2	<0.1	0.6
	Phoenix	2	.4	.3	.4
	Seligman	13	1.2	.2	.7
	Winslow	3	.6	.4	.5
Ark:	Little Rock	1	<.1	<.1	<.1
Calif:	Baker	13	.9	.3	.6
	Barstow	12	.7	<.1	.4
	Bishop	13	1.1	.2	.6
	Death Valley Junction	13	.9	.2	.6
	Furnace Creek	13	1.0	.4	.6
	Indio	3	.5	.2	.4
	Lone Pine	8	.8	.4	.5
	Needles	2	1.2	.8	.9
	Ridgecrest	13	.7	.3	.5
	Shoshone	13	1.1	.3	.6
Colo:	Denver	3	.4	.2	.3
	Durango	3	.3	<.1	.2
Idaho:	Boise	2	.2	.1	.1
	Idaho Falls	3	.3	.2	.3
	Preston	3	.4	<.1	.2
	Twin Falls	3	.3	<.1	.2
Iowa:	Iowa City	3	.2	.1	.2
	Sioux City	3	.4	.1	.3
Kans:	Dodge City	3	.3	.1	.2
La:	Lake Charles	3	.4	.3	.3
	Monroe	3	.4	<.1	.2
	New Orleans	3	.3	.2	.3
Minn:	Minneapolis	3	.3	<.1	.2
Mo:	Clayton	3	.2	.2	.2
	Joplin	3	.3	.2	.2
	St. Joseph	2	.3	.3	.3
Nebr:	North Platte	3	.2	.2	.2
Nev:	Alamo	13	1.0	.4	.6
	Austin	13	.7	.2	.3
	Battle Mountain	3	.3	.2	.3
	Beatty	13	1.0	<.1	.5
	Blue Eagle Ranch (Currant)	13	1.3	.2	.5
	Blue Jay	13	.9	<.1	.5
	Caliente	13	.7	<.1	.5
	Currant Ranch	2	.4	.3	.3
	Currie	3	.4	.2	.3
	Diablo	13	1.0	<.1	.6
	Duckwater	13	.8	<.1	.3
	Elko	3	.4	<.1	.3

Table 1. Summary of gross beta radioactivity concentration in air, April 1974—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Nev:	Ely	13	.6	.2	.4
	Eureka	13	.9	.1	.4
	Fallini's Twin Springs Ranch	13	.9	<.1	.5
	Fallon	3	.6	.2	.4
	Frenchman Station	3	.3	<.1	.1
	Geyser Ranch (Pioche)	6	.7	.4	.5
	Goldfield	13	1.1	.1	.5
	Groom Lake	13	1.0	.3	.6
	Hiko	13	1.0	.3	.6
	Indian Springs	13	.6	.3	.5
	Las Vegas	14	1.0	<.1	.6
	Lathrop Wells	12	.8	<.1	.5
	Lida	12	.9	<.1	.5
	Lovelock	3	.5	<.1	.3
	Lund	13	.8	.2	.5
	Mesquite	13	.7	<.1	.4
	Nyala	13	1.2	.3	.6
	Pahrump	13	.8	<.1	.5
	Pioche	13	.9	.3	.6
	Reno	3	.6	.2	.4
	Round Mountain	13	.9	.3	.5
	Scotty's Junction	13	.9	.2	.5
	Stone Cabin Ranch	13	.7	.3	.4
	Sunnyside	13	.6	.2	.4
	Tonopah	13	1.0	.2	.5
	Tonopah Test Range	13	.8	.2	.5
	Warm Springs	4	.8	<.1	.5
	Warm Springs Ranch	13	.8	<.1	.5
	Wells	3	.4	<.1	.3
	Winnemucca	3	.2	<.1	.1
N. Mex:	Albuquerque	3	.7	.4	.5
	Carlsbad	3	.5	.3	.4
Okla:	Muskogee	3	.1	.1	.1
Oreg:	Burns	1	.1	.1	.1
S. Dak:	Aberdeen	3	.3	<.1	.2
	Rapid City	3	.2	<.1	.1
Tex:	Abilene	3	.5	.4	.4
	Amarillo	3	.6	.3	.4
	Austin	3	.5	.2	.4
	Fort Worth	3	.5	.3	.4
Utah:	Bryce Canyon	3	.7	.3	.5
	Cedar City	7	.7	<.1	.4
	Delta	13	.6	<.1	.4
	Dugway	3	.4	.2	.3
	Enterprise	3	.7	.2	.4
	Garrison	13	.9	.2	.5
	Logan	3	.5	.1	.2
	Milford	13	1.8	0.2	0.5
	Monticello	3	.3	.2	.2
	Parowan	3	.5	.3	.4
	Provo	3	.3	.1	.2
	St. George	12	.8	.1	.6
	Vernal	3	.4	.2	.3
	Wendover	2	.2	.2	.2
Wash:	Seattle	3	.1	<.1	.1
	Spokane	3	.6	.1	.3
Wyo:	Rock Springs	3	.2	.1	.1
	Worland	3	.3	.2	.2

3. Canadian Air and Precipitation Monitoring Program,[2] April 1974

Radiation Protection Bureau
Department of National Health and Welfare

The Radiation Protection Bureau of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Atmospheric Environment Service of the Department of the Environment. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are con-

Figure 4. Canadian air and precipitation sampling stations

Table 3. Canadian gross beta radioactivity in surface air and precipitation, March 1974

Location	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	5	0.09	0.05	0.07	103.4	5.2
Coral Harbour	5	.12	.05	.08	138.8	2.0
Edmonton	5	.14	.07	.11	121.6	3.3
Ft. Churchill	2	.09	.04	.07	120.2	1.0
Fredericton	5	.17	.05	.11	63.1	8.5
Goose Bay	5	.07	.05	.06	21.6	1.5
Halifax	4	.11	.02	.07	32.1	2.7
Inuvik	5	.11	.04	.08	276.1	.7
Montreal	5	.12	.04	.08	78.4	7.6
Moosonee	4	.14	.08	.11	72.3	3.9
Ottawa	5	.10	.03	.07	110.0	7.4
Quebec	5	.14	.06	.10	74.8	7.8
Regina	5	.14	.06	.10	83.1	1.5
Resolute	5	.10	.03	.07	60.0	.4
St. John's, Nfld	4	.06	.01	.04	25.8	3.9
Saskatoon	5	.15	.05	.10	98.9	1.3
Sault St. Marie	5	.17	.07	.12	89.8	7.2
Thunder Bay	5	.11	.05	.08	85.2	6.2
Toronto	NS				111.8	9.3
Vancouver	5	.09	.03	.06	12.6	1.3
Whitehorse	5	.15	.04	.10	347.7	.7
Windsor	NS				92.5	6.0
Winnipeg	5	.18	.08	.13	65.5	3.8
Yellowknife	5	.09	.06	.08	153.8	.7
Network summary	104	0.18	0.01	0.09	101.6	3.9

NS, no sample.

tained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for April 1974 are presented in table 3.

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).
(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).
(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).
(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).
(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

3. Pan American Air Sampling Program
April 1974

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The April 1974 air monitoring results from the participating countries are given in table 4.

Table 4. Summary of gross beta radioactivity in Pan American surface air, April 1974

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average *
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	0			
Chile:	Santiago	27	0.04	0.00	0.02
Colombia:	Bogota	18	.09	.00	.02
Ecuador:	Cuenca	7	.01	.00	.00
	Guayaquil	20	.04	.01	.02
	Quito	6	.02	.00	.01
Guyana:	Georgetown	2	.05	.04	.05
Jamaica:	Kingston	0			
Peru:	Lima	17	.02	.00	.01
Trinidad and Tobago:	Port of Spain	0			
Venezuela:	Caracas	4	.04	.01	.03
Pan American summary		101	0.09	0.00	0.02

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

Figure 5. Pan American Air Sampling stations

5. California Air Sampling Program
April 1974

Radiologic Health Section California Department of Health

The Radiologic Health Section of the California Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

One of the objectives of the program is to evaluate the possibility that fixed effluent sources contribute to particulate activity in the air. Consequently, data from continuous air samplers placed in proximity to nuclear facilities are compared with those from similar
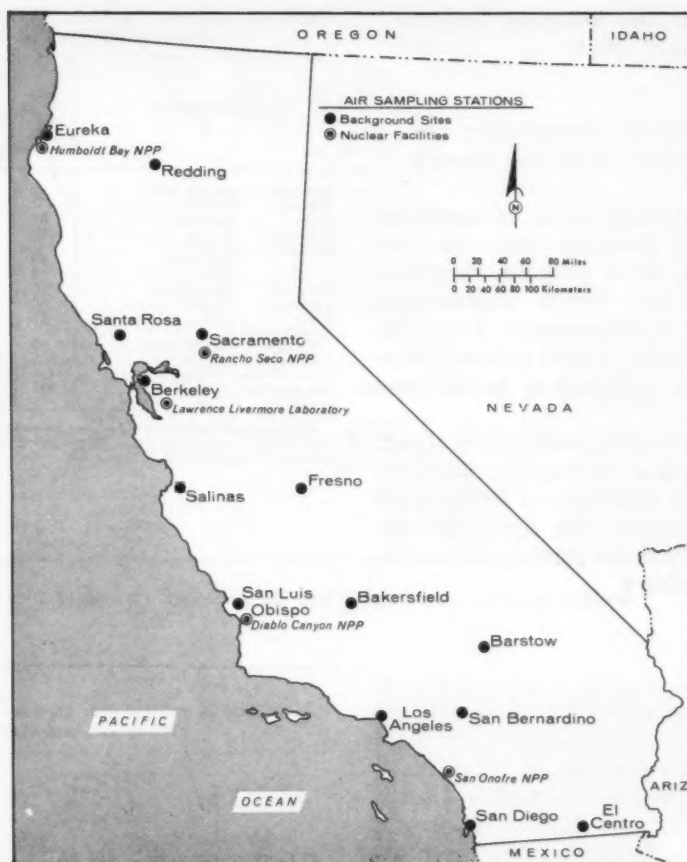
Figure 6. California air sampling program stations

equipment in nearby communities and at several "background" stations.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health. The filters are analyzed for gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. The monthly sample results are presented quarterly. Table 5 presents the gross beta radioactivity in air for April 1974.

Table 5. Gross beta radioactivity in California air
April 1974

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	21	1.24	0.10	0.48
Barstow	30	1.06	.12	.61
Berkeley	30	.95	.11	.30
Diablo Canyon Nuclear Power Plant	7	.45	.17	.31
El Centro	20	1.60	.17	.70
Eureka	21	.49	.05	.21
Fresno	19	.90	.13	.46
Humboldt Bay Nuclear Power Plant	3	.11	.02	.06
Livermore	21	.96	.00	.36
Los Angeles	21	.71	.16	.41
Rancho Seco Nuclear Power Plant	13	.77	.16	.36
Redding	16	1.70	.17	.82
Sacramento	22	.61	.10	.29
Salinas	23	.48	.15	.26
San Bernardino	16	.89	.29	.56
San Diego	22	.74	.16	.37
San Luis Obispo	18	.77	.00	.30
San Onofre Nuclear Generating Station	3	.35	.29	.32
Santa Rosa				
Summary	326	1.70	0.00	0.40

6. ERAMS Plutonium and Uranium in Air Component July–September 1973

Office of Radiation Programs Environmental Protection Agency

The Environmental Radiation Ambient Monitoring System (ERAMS), which began in July 1973, was developed from previously operating radiation montoring networks to form a single monitoring system which is more responsive to current and projected sources of environmental radiation.

The ERAMS Plutonium and Uranium in Air Component is a restructuring of the Plutonium in Airborne Particulates network, which was comprised of monthly plutonium analyses from selected Radiation Alert Network sampling stations. The current sampling stations have been reoriented towards fuel processing, fuel reprocessing, and other facilities using plutonium or uranium. The Plutonium and Uranium in Air Component consists of 19 air sampling stations (figure 7) and are taken from the 19 continuously operated sampling stations of the ERAMS Gross Radioactivity and Deposition Component. Plutonium-238, plutonium-239, uranium-234, and uranium-238 analyses are performed on a quarterly composite from each of the 19 sampling stations by the Eastern Envi-
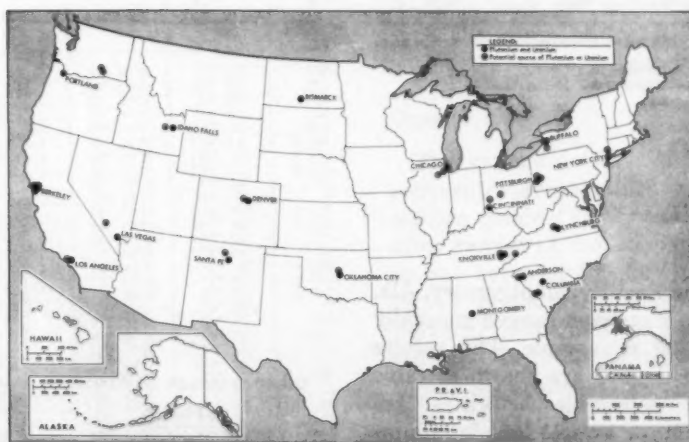
Figure 7. ERAMS Plutonium and Uranium in Air Component sampling stations

Table 6. ERAMS Plutonium and Uranium in Air Component, July-September 1973

Sampling location		Concentration [a] (aCi/m³ ± 2σ)				$^{239}Pu/^{238}Pu$	Potential sources of plutonium or uranium
		^{234}U	^{238}U	^{238}Pu	^{239}Pu		
Ala:	Montgomery	16.7± 1.7	16.0±1.6	1.0±0.4	6.6±0.1	6± 3	Background
Calif:	Berkeley	7.4± 1.0	5.9± .9	.2± .2	4.2± .7	19±14	General Electric Company San Jose, Calif.
							Lawrence Berkeley Laboratory Berkeley, Calif.
							Lawrence Livermore Laboratory Livermore, Calif.
	Los Angeles	28.8± 2.3	27.3±2.2	1.1± .3	5.6± .7	5± 1	Atomic International Canoga Park, Calif.
Colo:	Denver	40.8± 3.3	44.9±3.6	1.7± .5	8.4±1.2	5± 2	Rocky Flats Plant Golden, Colo.
Idaho:	Idaho Falls	(b)					National Reactor Testing Station Idaho Falls, Idaho
Ill:	Chicago	(b)					Argonne National Laboratory Lemont., Ill.
							Midwest Fuel Reprocessing Plant Morris, Ill.
Nev:	Las Vegas	121 ± 7	66 ±4.4	0	8.8±1.2	-------	Nevada Test Site Las Vegas, Nev.
N. Mex:	Santa Fe	19.2± 1.9	19.3±1.9	1.5± .5	6.3±1.0	4± 2	Los Alamos Laboratory Los Alamos, N. Mex.
N.Y:	Buffalo	142 ±10	134 ±9	0	9.5±1.5	-------	Nuclear Fuel Services West Valley, N.Y.
	New York City	(b)					Gulf United Nuclear Fuels Pawling, N.Y.
N. Dak:	Bismarck	28.7± 1.8	30.6±1.9	2.2± .5	8.2±1.2	4± 1	Background
Ohio:	Columbus c	82.6± 5.8	79.8±5.6	1.6± .5	7.0±1.1	4± 2	Batelle Columbus Laboratory Columbus, Ohio
							Mound Laboratory Miamisburg, Ohio
Okla:	Oklahoma City	20.9± 2.0	20.8±2.0	.9± .3	6.5± .9	7± 2	Kerr-McGee Cimarron Plant Cresent, Okla.
Oreg:	Portland	11.6± 1.4	12.4±1.5	1.1± .3	5.6± .8	5± 2	Hanford Laboratories Richland, Wash.
							Exxon Nuclear Richland, Wash.
Pa:	Harrisburg d	24.7± 2.8	20.2±2.5	0	11.3±1.3	-------	Westinghouse Cheswick, Pa.
							NUMEC—Babcock & Wilcox Leechburgh, Pa.
S.C:	Anderson	(b)					Westinghouse Fuels Recycle Anderson, S.C.
							Savannah River Plant Aiken, S.C.
	Columbia	53.7± 3.9	48.6±3.5	.8± .2	5.5± .7	7± 2	Allied Gulf Nuclear Fuel Services Barnwell, S.C.
Tenn:	Knoxville	(b)					NFS Fuels Fabrication Plant Erwin, Tenn.
							Oak Ridge National Laboratory Oak Ridge, Tenn.
							LMFBR Demonstration Site Oak Ridge, Tenn.
Va:	Lynchburg	(b)					Babcock & Wilcox Lynchburg, Va.
Average		46.0	40.4	0.9	7.2	7	

[a] Any concentration less than the 2σ error has been reported as zero.
[b] Station to be established.
[c] Station to be relocated to Cincinnati.
[d] Station to be relocated to Pittsburgh.

ronmental Radiation Facility, Montgomery, Ala. The volume of the air sampled ranged generally between 700 to 1200 m³/sample. The results from July–September 1973 are shown in table 6. The minimum detectable activities are 20, 15, 15, and 15 fCi per sample for plutonium-238, plutonium-239, uranium-234, and uranium-238, respectively.

Other coverage in *Radiation Data and Reports:*

Surface Air Sampling Program—80th Meridian Network[1] January-December 1972

Health and Safety Laboratory
Atomic Energy Commission

The Health and Safety Laboratory (HASL) began its Surface Air Sampling Program in January 1963, as a continuation of the 80th Meridian Program conducted by the U.S. Naval Research Laboratory. The objective of this program is to study the spatial and temporal distribution of nuclear weapons debris and lead in the surface air.

The basic network consists of a line of sites approximately along the 80th meridian extending from about 81° N to 90° S latitudes (figure 1). Since 1963, a number of sites have been added to investigate the possible effects of longitude, elevation, and proximity to coastlines; and from late 1965 through March 1969, samplers were placed on four Atlantic Ocean weather ships to extend the surface air study over the marine environment (table 1).

Sampling and analytical procedures

Approximately 1400 cubic meters of ambient air per day are drawn through an 8-inch diameter microsorban filter for the land stations. For the ocean stations, about 2200 cubic meters of air per day were filtered by an 8- by 10-inch microsorban filter. Each filter is changed on the 1st, 8th, 15th, and 22nd of the month or more frequently if the filter becomes clogged with debris suspended in the air.

The filters are returned to HASL at the end of each month and under normal conditions, composited into monthly samples for analysis. Until late 1969, the composited sample was first gamma counted and then sent to a contractor laboratory for radiochemical analysis. In the current program, each sample is split into equal aliquots, one for gamma counting and spectrometry and the other for radiochemistry. Hence, half of each sample is now being kept and stored for possible future work.

Daily pump pressure drop and temperature readings also are submitted to HASL along with the samples for the purposes of computing the volume of sampled air.

Gamma analysis

The gamma activity of half of the monthly composites are obtained with an 8- by 4-inch sodium iodide (Tl) crystal as soon as possible after receipt of the samples. The integrated response between 100 keV and 3.0 MeV is corrected by the average detection efficiency (35 percent) of the gamma photons present in fallout; and the total gamma activities are reported in units of photons per minute per standard cubic meter.

Table 1. Station location, 1972

Site		Latitude	Longitude (west)	Elevation (meters)
Greenland:	Nord	81° 40′N	17° 00′	250
	Thule	76° 36′N	68° 35′	259
Ontario:	Moosonee	51° 16′N	80° 30′	10
N.Y:	New York City	40° 48′N	73° 58′	38
Utah:	Salt Lake City	40° 46′N	110° 49′	1 516
Colo:	Rocky Flats, No. 1	40° 00′N	105° 11′	1 830
	Rocky Flats, No. 2	40° 00′N	105° 11′	1 738
	Rocky Flats, No. 3	40° 00′N	105° 11′	2 013
Va:	Sterling	38° 58′N	77° 25′	76
Fla:	Miami	25° 49′N	80° 17′	4
Bahamas:	Bimini	25° 46′N	79° 22′	3
Hawaii:	Mauna Loa	19° 28′N	155° 36′	3 401
P.R:	San Juan	18° 26′N	66° 00′	10
Panama:	Balboa	8° 58′N	79° 34′	23
Venezuela:	La Aquada	8° 35′N	71° 9′	3 450
	Merida	8° 36′N	71° 10′	1 570
	Pico Espejo	8° 36′N	71° 10′	4 767
Ecuador:	Guayaquil	2° 10′S	79° 52′	7
Peru:	Lima	12° 01′S	77° 08′	13
Bolivia:	Chacaltaya	16° 21′S	68° 07′	5 220
Chile:	Antofagasta	23° 37′S	70° 16′	31
	Isle de Pasqua	27° 10′S	109° 26′	41
	Santiago	33° 27′S	70° 42′	520
	Puerto Montt	41° 27′S	72° 57′	7
	Punta Arenas	53° 08′S	70° 53′	35
Antarctica [a]		62° 56′S	60° 36′	16
		64° 49′S	62° 52′	10
South Pole station		90° 00′S		2 800

[a] The Chilean Antarctic station has moved at least three times within an area of about 2° latitude and longitude. For simplicity, the individual station names were dropped and all data grouped under "Antarctica."

Figure 1. HASL 80th Meridian Network sampling stations

Table 2. Strontium-89 concentrations in surface air, HASL, 1972[a]

Site	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
						Strontium-89 concentration (fCi/m³)						
Greenland: Nord	1.15	3.32	(c)	1.52	—	—	—	—	—	—	—	—
Thule	.99	4.13	b 1.04	b .19	2.39	4.29	3.15	3.30	1.62	.72	.50	b .37
Ontario: Moosonee	—	—	—	(c)	5.34	10.90	11.30	8.29	2.66	b	—	—
N.Y: New York City	1.22	4.21	b 1.01	b 1.81	7.51	11.50	15.20	b 9.41	b 3.38	1.47	b .72	b .29
Utah: Salt Lake City	17.40	2.66	(c)	10.40	29.90	38.50	28.60	13.10	5.71	3.02	b .90	b .90
Colo: Rocky Flats, No. 1	11.90	1.91	b 1.85	8.82	20.50	25.60	13.00	7.28	—	.87	.85	.81
Rocky Flats, No. 2	—	—	—	—	—	—	18.30	9.97	2.34	1.03	1.19	.57
Rocky Flats, No. 3	—	—	—	—	—	—	—	—	—	(c)	1.59	.94
Va: Sterling	3.38	4.16	b 1.19	3.65	5.63	12.50	7.30	6.39	2.61	1.67	b .69	b .28
Fla: Miami	—	3.19	2.85	15.30	15.50	11.20	8.91	5.90	2.02	.99	.91	b .48
Bahamas: Bimini	—	b .97	—	—	—	—	—	—	—	—	—	—
Hawaii: Mauna Loa	8.25	1.72	1.87	33.80	37.70	32.40	17.70	4.44	2.02	.82	.75	b .40
Puerto Rico: San Juan	1.27	.98	b .53	14.30	11.40	—	9.64	4.78	1.53	.33	b .40	b .32
Panama: Balboa	6.30	.95	(c)	4.90	5.74	—	4.22	2.63	b .57	b .09	b .16	(c)
Venezuela: La Aquada	—	—	—	—	—	—	—	1.02	b .14	—	—	—
Merida	—	—	—	—	—	—	—	1.27	.25	—	—	—
Pico Espejo	—	—	—	—	—	—	.91	.36	(c)	.16	b .30	b .30
Ecuador: Guayaquil	.96	.91	(c)	.58	b .24	b 0.25	.32	4.01	b .66	b .35	b .24	(c)
Peru: Lima	25.20	9.08	10.30	3.62	b 1.42	1.23	8.77	9.08	b 3.09	b .40	b .65	(c)
Bolivia: Chacaltaya	5.74	4.70	1.36	1.39	2.06	3.27	3.59	14.90	.27	b .69	b .33	b .22
Chile: Antofagasta	10.40	11.00	7.11	2.88	2.13	1.71	38.00	22.30	1.99	b .79	1.09	b 2.39
Isle de Pasqua	6.28	4.43		1.58	1.19	b .38	1.55	1.03	b .40	b .20	b .13	b .59
Santiago	—	4.73	b 5.22	b 4.83	b .69	2.14	22.30	5.80	.99	b 3.03	(c)	(c)
Puerto Montt	7.82	b 7.47	6.95	3.67	b 1.24	.73	b .64	.76	b 1.03	—	.20	b .70
Punta Arenas	—	—	—	—	—	—	—	.46	.20	—	(c)	(c)
South Pole station	15.20	(c)	b 8.56	5.92	b 2.12	b 1.11	b .33	.90	b .98	—	b .38	(c)

a Errors are less than 20 percent except:
b Error between 20—100 percent;
c Error greater than 100 percent.
—. no data reported.

Gamma spectra of the monthly composites are obtained using a lithium-drifted germanium diode (GeLi) system. Concentrations of the gamma emitting nuclides, beryllium-7, zirconium-95, cesium-137, and cerium-144 are determined by computer resolution of the spectra. Beginning in June 1970, all results from these nuclides, reported in the tables, were obtained using this system.

Table 3. Strontium-90 concentrations in surface air, HASL, 1972[a]

Site	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
						Strontium-90 concentration (fCi/m³)						
Greenland: Nord	0.61	0.64	1.04	1.20	—	—	—	—	—	—	—	—
Thule	.09	1.09	1.73	.98	1.01	.68	.42	.44	.36	.27	.38	.49
Ontario: Moosonee	—	—	—	1.81	1.04	1.39	1.58	1.07	.42	—	—	—
N.Y: New York City	.29	.99	1.35	1.58	1.48	1.61	1.68	1.25	.82	.51	.33	b .36
Utah: Salt Lake City	1.74	1.56	2.96	2.72	3.48	3.22	2.48	2.00	1.46	.36	.72	b .50
Colo: Rocky Flats, No. 1	1.20	1.32	2.37	2.08	1.64	1.72	1.16	.96	—	.34	.38	.59
Rocky Flats, No. 2	—	—	—	—	—	—	b .89	1.31	.67	.41	.46	.52
Rocky Flats, No. 3	—	—	—	—	—	—	—	—	—	1.01	.54	.61
Va: Sterling	.80	.95	1.14	1.82	.77	1.57	.73	.75	.56	.69	.24	.27
Fla: Miami	—	1.28	1.58	2.95	1.08	1.01	.98	.73	.45	.42	.40	.50
Bahamas: Bimini	—	1.40	—	—	—	—	—	—	—	—	—	—
Hawaii: Mauna Loa	2.05	2.09	1.60	2.12	2.32	1.96	1.66	.66	.58	.47	.41	.57
Puerto Rico: San Juan	.63	.74	.97	1.89	1.19	—	.99	.73	.39	.17	.32	.23
Panama: Balboa	.79	.64	.81	1.10	.34	—	.43	.42	b .11	b .06	.11	.31
Venezuela: La Aquada	—	—	—	—	—	—	—	.17	.10	—	—	—
Merida	—	—	—	—	—	—	—	.18	.11	—	—	—
Pico Espejo	—	—	—	—	—	—	.07	.09	.04	.04	b .10	.33
Ecuador: Guayaquil	.18	.19	.14	.25	.13	.12	b .03	.14	.28	.38	.29	.35
Peru: Lima	3.59	1.54	1.91	1.10	.40	.77	.58	.78	3.36	1.44	2.01	1.49
Bolivia: Chacaltaya	.58	.83	.33	.40	.61	.76	.49	.76	.50	1.19	.70	.41
Chile: Antofagasta	1.73	2.06	1.99	1.57	.78	1.12	1.65	1.69	1.71	1.65	1.34	.47
Isle de Pasqua	1.00	.98	—	.42	.44	.38	.47	.66	.67	.60	.61	.35
Santiago	—	1.13	2.33	1.30	.77	.91	1.01	1.07	1.51	1.87	1.59	1.29
Puerto Montt	1.43	2.37	1.52	.67	.70	.45	.41	.54	.64	—	.40	.47
Punta Arenas	—	—	—	—	—	—	—	.27	.31	.26	.25	.40
South Pole station	3.48	1.77	1.19	.93	.85	.84	.34	.62	.87	.79	.85	.20

a Errors are less than 20 percent except:
b Error between 20—100 percent;
—, no data reported.

Radiochemical analyses

The other halves of the monthly composites are sent to a contractor laboratory for radiochemical analyses.

There were no major weapon test series from the end of 1962 until May 1966. Consequently, only the longer-lived artificially produced radionuclides were present in the filters collected during this period and emphasis was given to the determination of manganese-54, iron-55, strontium-90, cadmium-109, cesium-137, cerium-144, plutonium-238, and plutonium-239. In samples collected after French or Chinese atmospheric weapons tests additional short-lived nuclides were analyzed, such as strontium-89, zirconium-95, and cerium-141.

The longer-lived fission products and plutonium-239 concentrations should describe the general distribution in surface air in all previous nuclear weapon debris which was transferred from the lower stratosphere to the troposphere during the collection period of this report. Other tracer nuclides can be associated with debris from a single detonation or series of detonations. Manganese-54 and iron-55 were produced in large quantities in the 1961 and 1962 test series. Cadmium-109 was generated by the U.S. high altitude test over Johnston Island on July 9, 1962. While plutonium-238 is present in low concentrations in nuclear weapons debris, about 17 000 curies of plutonium-238 was disseminated at high altitude in the stratosphere on April 21, 1964 during the reentry burnup of a SNAP–9A power source.

As the levels of any of the radionuclides drop to below practical detection limits they are eliminated from the radiochemical program; thus, cadmium-109 was not analyzed after the end of 1967.

Most of the analyses of surface air samples were carried out from July 1969 to the present by the LFE-Environmental Analysis Laboratories.

Results

The radioactivity concentrations in surface air during January–December 1972 are presented in tables 2 through 8. The sites are listed according to latitude beginning with the

Table 4.   Zirconium-95 concentrations in surface air, HASL, 1972[a]

Site		Zirconium-95 concentration (fCi/m³)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	2.27	b 2.47	b 0.82	4.54	—	—	—	—	—	—	—	—
	Thule	2.21	b 1.52	b 1.44	6.70	20.10	20.50	7.05	4.23	(c)	b 0.43	(c)	(c)
Ontario:	Moosonee	—	—	—	24.60	22.40	28.20	12.60	7.37	b 1.18	—	—	—
N.Y:	New York City	b 8.39	2.85	b 1.81	81.40	25.60	24.50	13.40	5.81	2.83	b .67	(c)	b 0.82
Utah:	Salt Lake City	60.90	6.04	b 4.55	86.70	82.40	51.40	27.80	9.55	4.41	b 2.18	b 1.04	(c)
Colo:	Rocky Flats, No. 1	34.20	3.45	5.33	80.80	57.10	30.20	13.10	b 9.10	—	(c)	b .90	b 1.29
	Rocky Flats, No. 2	—	—	—	—	—	—	13.50	7.87	b 1.50	(c)	(c)	(c)
	Rocky Flats, No. 3	—	—	—	—	—	—	—	—	—	b 3.96	b 1.15	b .41
Va:	Sterling	9.67	2.71	1.53	26.10	19.00	24.40	11.50	4.50	(c)	b .79	b .45	(c)
Fla:	Miami	b 8.63	2.96	3.26	120.00	41.90	16.50	8.52	5.20	2.13	b 1.08	b .45	b .56
Hawaii:	Mauna Loa	7.49	b 4.92	2.85	145.00	91.00	34.90	15.10	(c)	(c)	(c)	(c)	(c)
Puerto Rico:	San Juan	(c)	2.42	b 1.77	59.70	36.00	—	10.40	12.20	1.35	b .31	(c)	2.01
Panama:	Balboa	2.66	b 2.66	1.59	4.87	8.51	—	4.45	2.13	b .91	(c)	(c)	(c)
Venezuela:	La Aquada	—	—	—	—	—	—	—	—	—	(c)	(c)	(c)
	Merida	—	—	—	—	—	—	—	—	—	(c)	(c)	b .30
	Pico Espejo	—	—	—	—	—	—	—	—	—	(c)	(c)	b .48
Ecuador:	Guayaquil	8.72	3.99	(c)	3.08	1.23	1.60	b 2.97	10.20	b 4.31	—	b .39	(c)
Peru:	Lima	71.90	21.80	14.40	12.10	2.68	5.31	13.50	33.60	6.14	b 1.48	b 2.11	b .71
Bolivia:	Chacaltaya	10.30	10.50	2.33	b 4.70	4.89	4.56	6.28	20.30	—	—	b .68	(c)
Chile:	Antofagasta	28.90	23.10	19.90	11.10	4.19	6.95	53.70	57.60	2.84	b 2.09	b 1.44	(c)
	Isle de Pasqua	12.20	12.10	—	3.33	3.62	b 1.80	b 12.50	b 2.09	3.51	(c)	b .60	(c)
	Santiago	44.70	20.30	23.70	16.10	5.59	6.05	31.30	b 11.70	3.37	b 1.14	(c)	(c)
	Puerto Montt	21.50	21.90	16.70	7.18	4.06	b 2.16	b 1.19	b 4.86	b 4.83	—	b 3.48	5.12
	Punta Arenas	(c)	—	—	—	—	—	—	—	—	(c)	—	(c)
Antarctica:		—	—	—	—	—	(c)	—	—	—	—	—	—
South Pole station		36.20	b 18.00	b 13.20	b 2.64	3.99	b 1.81	(c)	b 1.81	b 1.03	b .90	(c)	b .47

* Errors are less than 20 percent except:
b Error between 20—100 percent;
c Error greater than 100 percent.
—, no data reported.

Table 5. Cesium-137 concentrations in surface air, HASL, 1972 [a]

Site		Cesium-137 concentration (fCi/m³)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	1.21	1.19	1.57	2.27	—	—	—	—	—	—	—	—
	Thule	1.24	1.21	2.31	1.54	1.77	1.48	0.74	1.04	0.57	0.37	0.42	0.87
Ontario:	Moosonee	—	—	—	2.69	2.93	2.60	1.84	1.70	.73	—	—	—
N.Y:	New York City	[b]2.44	1.84	2.14	3.17	2.83	2.62	2.22	1.56	1.24	.79	.62	.57
Utah:	Salt Lake City	4.08	3.16	4.03	4.50	6.55	4.97	4.61	2.97	1.99	1.11	[b]1.03	[b].66
Colo:	Rocky Flats, No. 1	2.00	2.00	3.44	2.99	3.30	2.77	2.03	1.90	—	.65	.70	.79
	Rocky Flats, No. 2	—	—	—	—	—	—	2.46	1.93	.96	.65	.71	.76
	Rocky Flats, No. 3	—	—	—	—	—	—	—	—	—	.75	.97	.98
Va:	Sterling	1.73	1.91	2.04	2.89	2.42	2.51	2.01	1.15	.90	.75	.86	.45
Fla:	Miami	2.37	2.32	3.47	5.16	2.95	1.98	1.54	1.48	.87	.80	.63	.85
Bahamas:	Bimini	—	2.42	—	—	—	—	—	—	—	—	—	—
Hawaii:	Mauna Loa	3.44	3.77	2.25	6.27	3.44	2.61	2.25	1.48	[b].89	.69	.43	1.12
Puerto Rico:	San Juan	[b]1.05	1.59	[b]2.25	2.94	1.97	—	1.44	2.62	.62	.51	.47	.46
Panama:	Balboa	1.10	[b]1.73	1.25	1.96	.65	—	1.66	.53	[b].25	[b].22	[b].06	.55
Venezuela:	La Aquada	—	—	—	—	—	—	—	—	—	.19	[b].10	[b].33
	Merida	—	—	—	—	—	—	—	—	—	[b].10	[b].17	.59
	Pico Espejo	—	—	—	—	—	—	—	—	—	—	—	—
Ecuador:	Guayaquil	.88	.53	(c)	[b].29	[b].26	.33	.50	.32	[b].31	.56	.70	.28
Peru:	Lima	6.32	2.25	2.16	2.30	.62	1.19	1.27	1.51	4.12	2.07	2.90	1.84
Bolivia:	Chacaltaya	[b].88	[b].90	.47	[b].70	[b]1.08	.93	.78	1.43	.82	2.05	.94	.66
Chile:	Antofagasta	3.05	2.97	[b]2.50	2.08	1.07	1.50	2.80	2.32	2.17	2.15	2.04	1.23
	Isle de Pasqua	1.49	1.39	—	.76	.95	.56	.60	1.13	1.12	.99	.85	.51
	Santiago	5.11	2.26	3.13	2.96	1.25	1.46	1.92	[b]1.67	2.38	3.16	3.64	2.67
	Puerto Montt	2.54	3.08	2.50	1.23	.71	.56	.51	.79	1.23	—	.69	[b].21
	Punta Arenas	—	—	—	—	—	—	—	.49	.51	.34	.45	.54
Antarctica		(c)	—	—	—	—	.29	—	—	—	—	—	—
South Pole station		5.20	2.25	2.07	1.25	1.03	.94	.50	.81	.92	1.05	1.24	1.00

[a] Errors are less than 20 percent except:
[b] Error between 20—100 percent;
[c] Error greater than 100 percent.
—, no data reported.

Table 6. Cerium-144 concentrations in surface air, HASL, 1972 [a]

Site		Cerium-144 concentration (fCi/m³)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	7.56	6.60	8.97	11.90	—	—	—	—	—	—	—	—
	Thule	10.60	8.41	14.40	8.26	13.10	11.80	6.23	5.62	3.82	1.72	2.29	3.02
Ontario:	Moosonee	—	—	—	22.40	18.00	19.50	12.10	10.90	3.47	—	—	—
N.Y:	New York City	[b]16.40	11.70	12.80	27.40	19.30	19.50	15.70	9.11	6.65	3.49	2.15	1.76
Utah:	Salt Lake City	34.80	19.90	24.60	37.20	45.60	38.70	30.70	15.30	10.20	4.74	5.43	3.13
Colo:	Rocky Flats, No. 1	20.70	12.10	18.80	27.10	30.70	23.30	14.90	9.28	—	2.55	2.64	2.57
	Rocky Flats, No. 2	—	—	—	—	—	—	15.10	10.40	4.54	3.05	2.97	2.74
	Rocky Flats, No. 3	—	—	—	—	—	—	—	—	—	2.85	3.95	3.55
Va:	Sterling	14.70	11.70	11.60	22.80	16.60	18.80	11.80	6.92	4.64	3.68	1.68	1.34
Fla:	Miami	13.30	14.30	21.00	46.30	23.60	13.20	9.68	7.83	3.97	4.53	2.05	2.73
Bahamas:	Bimini	—	17.40	—	—	—	—	—	—	—	—	—	—
Hawaii:	Mauna Loa	27.10	19.70	12.70	56.30	42.00	21.80	14.00	6.55	3.59	2.30	2.14	3.76
Puerto Rico:	San Juan	9.53	8.36	13.00	26.10	17.60	—	10.50	15.70	2.58	1.87	1.46	1.28
Panama:	Balboa	7.17	6.71	7.42	11.20	5.05	—	5.53	3.04	[b]1.12	[b].72	[b].74	[b]1.55
Venezuela:	La Aquada	—	—	—	—	—	—	—	—	—	[b].67	[b].33	1.42
	Merida	—	—	—	—	—	—	—	—	—	.83	[b].79	1.12
	Pico Espejo	—	—	—	—	—	—	—	—	—	[b].57	[b].80	1.67
Ecuador:	Guayaquil	9.93	6.07	1.43	4.55	2.63	2.30	3.74	3.78	[b]2.49	3.53	4.54	[b].94
Peru:	Lima	80.10	25.40	26.10	23.80	5.33	12.20	10.50	14.40	30.90	13.70	17.30	10.60
Bolivia:	Chacaltaya	12.00	13.90	3.18	6.12	8.87	10.40	5.80	10.70	5.37	10.90	4.54	2.93
Chile:	Antofagasta	35.70	35.20	29.70	22.30	10.20	14.30	26.80	25.30	14.90	14.90	12.40	8.30
	Isle de Pasqua	13.20	15.90	—	6.65	7.01	4.48	6.81	7.21	6.13	6.30	5.57	2.57
	Santiago	47.30	26.40	31.10	24.70	11.40	12.00	15.80	18.20	16.20	18.30	22.20	13.00
	Puerto Montt	31.30	35.70	21.00	12.70	7.68	5.11	4.61	6.56	6.99	—	3.05	2.90
	Punta Arenas	—	—	—	—	—	—	—	3.38	4.20	1.74	2.25	2.83
Antarctica		[b]3.74	—	—	—	—	4.59	—	—	—	—	—	—
South Pole station		48.70	19.80	14.80	11.00	19.10	8.52	3.86	5.51	6.19	6.54	6.71	4.92

[a] Errors are less than 20 percent except:
[b] Error greater than 100 percent.
—, no data reported.

Table 7. Plutonium-238 concentrations in surface air, HASL, 1972[a]

Site		Plutonium-238 concentration (aCi/m³)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	(c)	(c)	b 1.84	b 2.65	—	—	—	—	—	—	b 2.92	—
	Thule	(c)	(c)	b 4.17	(c)	b 1.63	—	—	—	—	—	—	(c)
Ontario:	Moosonee	—	—	—	(c)	b 2.51	b 2.29	b 2.60	b 1.31	(c)	—	—	—
N.Y:	New York City	12.00	b 4.16	b 2.25	b 3.59	b 15.20	8.44	9.12	(c)	46.30	9.08	b 3.87	b 9.82
Utah:	Salt Lake City	b 3.38	b 7.18	b 4.12	b 3.54	10.00	b 5.67	b 10.40	30.10	b 3.81	b 2.38	(c)	—
Colo:	Rocky Flats, No. 1	105.00	37.70	97.90	32.20	49.10	131.00	98.60	—	—	33.70	b 9.30	35.10
	Rocky Flats, No. 2	—	—	—	—	—	—	b 4.32	(c)	b 3.51	b 7.54	(c)	(c)
	Rocky Flats, No. 3	—	—	—	—	—	—	—	—	(c)	(c)	(c)	(c)
Va:	Sterling	(c)	(c)	b 2.37	b 2.01	b 2.20	b 1.97	b 2.04	b 6.46	(c)	(c)	(c)	(c)
Fla:	Miami	b 8.56	(c)	b 3.54	b 6.06	(c)	(c)	(c)	(c)	b 1.35	(c)	(c)	(c)
Bahamas:	Bimini	—	b 2.06	—	—	—	—	—	—	—	—	—	—
Hawaii:	Mauna Loa	b 4.02	(c)	(c)	b 4.66	b 7.06	b 4.08	b 1.80	(c)	(c)	(c)	(c)	(c)
Puerto Rico:	San Juan	(c)	(c)	—	b 3.24	b 1.51	—	b 1.37	(c)	(c)	(c)	(c)	(c)
Panama:	Balboa	b 2.40	(c)	b 2.03	b 2.97	(c)	—	b 1.41	(c)	(c)	(c)	(c)	(c)
Venezuela:	La Aguada	—	—	—	—	—	—	—	(c)	(c)	—	—	—
	Merida	—	—	—	—	—	—	—	—	b 7.07	—	—	—
	Pico Espejo	—	—	—	—	—	—	13.40	b 2.70	(c)	(c)	(c)	b 6.47
Ecuador:	Guayaquil	(c)	(c)	—	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)
Peru:	Lima	b 4.76	(c)	2.38	b 1.63	(c)	b 2.36	b 5.59	b 2.70	b 7.42	b 3.21	b 2.29	(c)
Bolivia:	Chacaltaya	(c)	(c)	(c)	(c)	(c)	b 2.94	b 2.05	9.68	b 9.40	(c)	(c)	(c)
Chile:	Antofagasta	1.64	—	(c)	b 3.05	b 2.17	b 4.40	20.10	236.00	—	b 1.62	b 8.44	b 7.08
	Isle de Pasqua	(c)	b 2.18	—	(c)	(c)	b 1.16	b 5.09	(c)	(c)	b 2.12	b 1.77	(c)
	Santiago	b 3.49	b 3.76	(c)	(c)	(c)	b 3.80	20.10	b 9.73	b 5.31	(c)	(c)	(c)
	Puerto Montt	22.90	b 4.75	(c)	(c)	b 1.96	(c)	b 3.67	b 2.07	(c)	(c)	b .56	(c)
	Punta Arenas	(c)	—	(c)	—	(c)	(c)	(c)	—	(c)	(c)	—	(c)
South Pole station		b 3.39	(c)	(c)	(c)	(c)	(c)	(c)	(c)	b 1.30	(c)	(c)	(c)

a Errors are less than 20 percent except:
b Error between 20—100 percent;
c Error greater than 100 percent.
—, no data reported.

Table 8. Plutonium-239 concentrations in air, HASL, 1972[a]

Site		Plutonium-239 concentration (aCi/m³)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	b 9.57	17.70	21.30	29.20	26.10	23.50	11.80	13.00	9.64	12.10	8.42	11.90
	Thule	9.88	29.00	39.80	18.20	35.90	44.60	36.80	31.10	13.50	—	—	—
Ontario:	Moosonee	—	—	—	32.80	—	—	—	—	—	—	—	—
N.Y:	New York City	23.50	23.60	26.20	b 31.10	36.90	48.70	b 47.80	38.60	20.40	15.00	b 9.18	b 5.31
Utah:	Salt Lake City	106.00	43.70	52.10	52.90	93.90	91.70	105.00	b 96.90	42.20	17.20	b 15.40	b 10.50
Colo:	Rocky Flats, No. 1	5 430.00	1 670.00	4 610.00	1 460.00	2 080.00	6 610.00	4 720.00	1 380.00	—	1 620.00	498.00	1 860.00
	Rocky Flats, No. 2	—	—	—	—	—	—	99.00	55.50	119.00	508.00	48.50	45.20
	Rocky Flats, No. 3	—	—	—	—	—	—	—	—	—	21.90	18.50	25.60
Va:	Sterling	27.00	24.60	26.40	30.80	33.80	35.70	34.00	b 15.50	15.80	13.80	(c)	(c)
Fla:	Miami	b 39.50	35.30	59.30	61.80	44.00	23.70	24.80	24.80	15.00	15.80	12.20	11.70
Bahamas:	Bimini	—	42.40	—	—	—	—	—	—	—	—	—	—
Hawaii:	Mauna Loa	124.00	39.00	29.70	49.30	76.10	65.00	43.60	b 28.50	—	13.50	b 14.00	43.00
Puerto Rico:	San Juan	11.90	15.50	21.20	39.10	30.20	—	25.80	20.10	12.40	4.98	7.84	b 4.48
Panama:	Balboa	10.10	12.10	16.60	17.40	10.40	—	12.60	b 29.40	b 3.24	b 1.10	b 2.11	5.63
Venezuela:	La Aguada	—	—	—	—	—	—	—	b 8.86	b 2.15	—	—	—
	Merida	—	—	—	—	—	—	—	8.25	4.05	—	—	—
	Pico Espejo	—	—	—	—	—	—	5.60	b 1.12	—	b 3.97	b 3.70	b 14.30
Ecuador:	Guayaquil	6.09	5.48	4.74	3.76	4.82	b 5.32	230.00	45.30	b 4.92	6.78	b 6.40	b 8.09
Peru:	Lima	80.60	18.20	27.30	15.40	7.37	12.10	104.00	b 93.10	43.70	23.80	37.50	22.80
Bolivia:	Chacaltaya	b 7.34	10.60	b 4.18	6.06	11.70	13.00	23.50	137.00	8.23	20.80	b 10.50	13.10
Chile:	Antofagasta	18.20	27.10	19.20	22.50	14.30	b 21.00	44.00	319.00	27.80	29.10	21.70	23.60
	Isle de Pasqua	10.20	10.10	—	4.53	6.19	4.55	81.50	14.70	8.69	10.90	15.80	15.50
	Santiago	25.30	29.80	25.80	22.80	b 15.60	52.50	294.00	66.10	32.00	36.40	38.50	32.40
	Puerto Montt	138.00	26.40	16.70	9.07	7.95	7.22	8.59	14.50	b 14.30	—	8.15	9.70
	Punta Arenas	—	—	—	—	—	—	—	8.51	b 4.22	b 3.78	12.80	10.80
South Pole station		40.90	20.70	12.30	9.84	14.60	8.50	5.29	9.89	12.60	10.00	9.04	b 3.92

a Errors are less than 20 percent except:
b Error between 20—100 percent;
c Error greater than 100 percent.
—, no data reported.

most northern site at Nord, Greenland (table 1).

The concentrations are reported at the mid-point of the collection month for the plutonium isotopes and the fission products.

One standard deviation of the counting error for these data is always less than ±20 percent unless otherwise indicated.

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the levels of environmental contaminants including radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required. The complete environmental monitoring reports are available in a compendium report entitled "Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites, Calendar year 1972," WASH–1259. The portions of these reports dealing with radioactivity are summarized for *Radiation Data and Reports*. Statements interpreting the radioactivity data are those of the USAEC contractors. The units for the data as reported in WASH–1259 have been converted from the format required by the AEC to that used by *Radiation Data and Reports*. The Environmental Protection Agency has not independently nor critically reviewed the data or the conclusions derived therefrom.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for Feed Materials Production Center and Knolls Atomic Power Laboratory.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

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1. Feed Materials Production Center,[2] January–December 1972

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the Atomic Energy Commission (AEC). The location as related to populated areas is shown in figure 1. Cincinnati and Hamilton, the larger nearby communities, are situated 32 and 16 km from the center, respectively.

The primary work at the FMPC is the production of purified uranium metal and compounds for use at other AEC sites. A small amount of thorium is also processed.

Uranium production may begin with ore concentrates, recycled uranium from spent reactor fuel, or with various compounds from other AEC sites. Impure starting material is dissolved in nitric acid and the uranium is extracted into an organic liquid and then back-extracted into dilute nitric acid to yield a solution of uranyl nitrate.

Evaporation and heating convert the nitrate solution to uranium trioxide (UO_3) powder. This compound is reduced to uranium dioxide (UO_2) with hydrogen and then converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. Uranium metal is produced by reacting UF_4 and magnesium metal in a refractory-lined reduction vessel.

[2] Summarized from "Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites; Feed Materials Production Center, 1972."
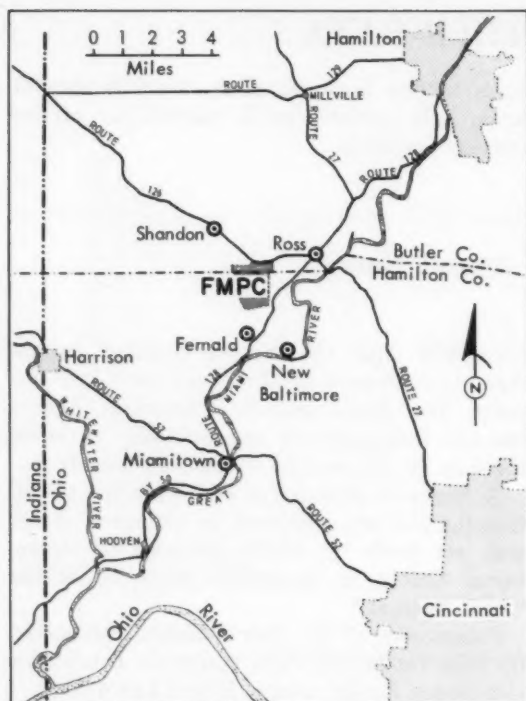
Figure 1. Area map of Feed Materials Production Center

This primary uranium metal is then remelted with scrap uranium metal to yield a purified uranium ingot which is rolled or extruded to form rods or tubes. Sections are then cut and machined to final dimensions. These machined cores are then shipped to other AEC sites for canning and final assembly into reactor fuel elements.

Thorium production steps, in general, are similar to those followed in uranium production. Final products may be purified thorium nitrate solution, solid thorium compounds, or metal.

Air monitoring

Conversion of impure uranium and thorium compounds to reactor-grade feed materials involves operations which generate radioactive dust, nuisance dusts, and corrosive mists or reaction products. Ventilation and air cleaning systems are used to confine this air and remove airborne contaminants, including valuable ma-

terial which is returned to the production processes. The filtered or scrubbed air is exhausted to the atmosphere. Sampling of these stack exhausts is maintained on a continuous schedule to determine the operating condition of the air cleaning systems.

During 1972, samples of particulate matter in air were continuously collected at six permanent sampling stations located on the project's outer boundary (figure 2). At each boundary station, a metered quantity of air is drawn through a filter which is changed weekly. Filters are weighed before use and then reweighed after changing to obtain the weight of collected dust. After reweighing, the filter and its collection of dust is dissolved in acid and the solutions are analyzed for uranium and alpha and beta radioactivity. After these analyses are completed the remaining solution is held to provide a long-term composite for thorium analyses. Frequent thorium analyses are not considered necessary because of the small amount of thorium processed and the low concentration of thorium found in the boundary samples.

Table 1 shows that the average radionuclide concentrations in air, and at boundary sampling stations, were no greater than 0.4 percent of their respective standards for offsite areas. It is concluded from these data that any offsite radiation exposure resulting from FMPC airborne contaminants would be a small fraction of the AEC standards (1).

Water monitoring

Each of the individual production plants on the project has sumps and equipment for the collection and initial treatment of process waste water. Uranium and thorium may be recovered as part of the treatment. Effluents from the plants are collected at a central facility, called the general sump, for additional treatment. The treated wastes are then discharged into a large pit where the solids settle to the bottom. Clear effluent from the pit is combined with the other water streams and discharged to the Great Miami River.

Water samples are collected at several points to determine the effect of the effluent upon the

Table 1. Radioactivity levels of airborne particulates, Feed Material Production Center, December 1972

Contaminant	Sampling point	Number of samples	Radionuclide concentration						Percent of standard	95-percent confidence limit	Detection level
			Maximum		Minimum		Average				
			(fCi/m³)	(ng/m³)	(fCi/m³)	(ng/m³)	(fCi/m³)	(ng/m³)			
Uranium [a]	BS 1	41	14.2	43	0.4	1	6.0	18	0.3		
	BS 2	44	54.4	162	.4	1	6.0	18	.3		
	BS 3	40	14.5	44	.9	3	9.1	27	.4	±5 fCi/m³	10 fCi/m³
	BS 4	46	14.9	45	.6	2	2.8	8	.1		
	BS 5	42	7.7	23	.7	2	3.5	11	.2		
	BS 6	43	19.0	57	1.2	4	6.8	22	.3		
Thorium [b]	BS 1	[d]1	NA	NA	NA	NA	.03	.3	<.001		
	BS 2	1	NA	NA	NA	NA	.02	.2	<.001		
	BS 3	1	NA	NA	NA	NA	.03	.3	<.001	±22 aCi/m³	11 aCi/m³
	BS 4	1	NA	NA	NA	NA	.02	.2	<.001		
	BS 5	1	NA	NA	NA	NA	.01	.1	<.001		
	BS 6	1	NA	NA	NA	NA	.01	.1	<.001		
Gross alpha radioactivity [c]	BS 1	41	14.2	NA	.5	NA	5.4	NA	.3		
	BS 2	44	41.7	NA	.6	NA	5.6	NA	.3		
	BS 3	40	13.8	NA	2.0	NA	7.7	NA	.4	±8 fCi/m³	10 fCi/m³
	BS 4	46	16.6	NA	.9	NA	3.2	NA	.2		
	BS 5	42	6.2	NA	1.2	NA	3.9	NA	.2		
	BS 6	43	20.7	NA	1.9	NA	6.4	NA	.3		
Gross beta radioactivity [c]	BS 1	41	95.8	NA	5.7	NA	54.0	NA	.005		
	BS 2	44	232.1	NA	12.0	NA	56.6	NA	.006		
	BS 3	40	100.5	NA	18.1	NA	60.1	NA	.006	±70 fCi/m³	10 fCi/m³
	BS 4	46	84.8	NA	11.6	NA	47.6	NA	.005		
	BS 5	42	90.1	NA	12.8	NA	53.6	NA	.005		
	BS 6	43	383.6	NA	26.8	NA	74.4	NA	.007		

[a] AEC radiation protection standard (1) 2000 fCi/m³ (natural uranium).
[b] AEC radiation protection standard (1) 1000 fCi/m³ (natural thorium).
[c] AEC radiation protection standard (1) 1 nCi/m³ (gross beta).
[d] Composite samples consisting of 13 continuous samples which cover the period, 1/16/72–3/30/72.
NA, not applicable.

Table 2. Radioactive contaminants in water, Feed Material Production Center, January-December 1972

Contaminant	Sampling point [a]	Number of samples	Radionuclide concentration						Percent of standard	95-percent confidence limit (pCi/liter)	Detection level (pCi/liter)	Standard (pCi/liter)
			Maximum		Minimum		Average					
			(pCi/liter)	(µg/liter)	(pCi/liter)	(µg/liter)	(pCi/liter)	(µg/liter)				
Uranium [b]	W1	53	67	200	<1	1	4	12	0.02	±0.5	0.10	[d]20 000
	W2	366	.50	1	.08	1	.17	<1	<.001	NA	NA	
	W3	53	17	50	<1	4	1	4	.005	±0.5	.10	
Thorium [b]	W2	[e]6	4.90x10⁻⁴	4.30x10⁻³	3.24x10⁻⁴	2.84x10⁻⁴	4.17x10⁻⁴	3.65x10⁻³	<.001	NA	NA	[d]1 000
Radium-226	W1	12	1.816	NA	<.454	NA	.908	NA	2.8	±.45	.45	[d]30
	W2	24	.074	NA	.002	NA	.022	NA	<.001	NA	NA	
	W3	12	.908	NA	<.454	NA	.454	NA	1.4	±.45	.45	
Radium-228	W1	12	.908	NA	.454	NA	.454	NA	1.4	±.45	.45	[d]30
	W2	24	.023	NA	.001	NA	.006	NA	<.001	NA	NA	
	W3	12	1.816	NA	<.454	NA	.908	NA	2.8	±.45	.45	
Dissolved alpha	W2	72	.970	NA	.094	NA	.293	NA	9.8	NA	NA	[e]3
Gross beta	W1	53	454	NA	4	NA	26	NA	2.6	±9	6	[e]1 000
	W2	366	4	NA	<1	NA	1	NA	.1	NA	NA	
	W3	53	86	NA	4	NA	15	NA	1.5	±9	6	

[a] See sampling locations shown in figure 2. W1—Miami River, upstream at Ross, Ohio; W2—Calculated addition to the river based on effluent analyses and river flow; W3—Miami River downstream at New Baltimore, Ohio.
[b] In accordance with Manual Chapter 0524 a curie of natural uranium means a total of 7.49×10^{10} dis/s and a curie of natural thorium means a total of 7.4×10^{4} dis/s.
[c] Each sample is a 1 month composite of daily 24 hour samples. Analyses were made for the first 6 months of 1972.
[d] See reference (1).
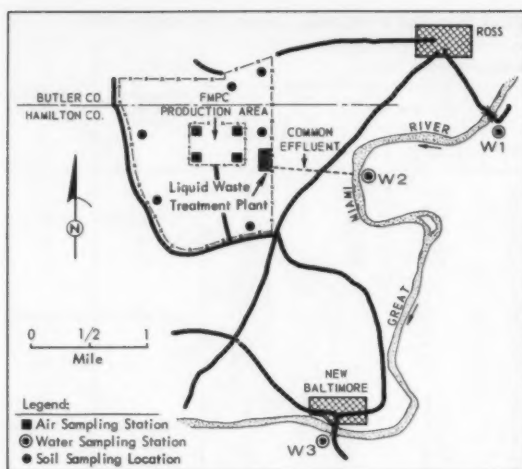[e] See reference (3).
NA, not applicable.

Figure 2. Air, water, and soil sampling stations, FMPC

river. Locations are shown in figure 2. At point W1, upstream from the effluent discharge, a daily grab sample is collected. At the final access point on the waste line, a Parshal Flume type water sampler collects a continuous sample which is proportional to the total flow. This sample is collected and analyzed on a daily basis. Results of these analyses, combined with river flow measurements, are used to calculate contaminant concentrations added to the river at point W2. At point W3, downstream on the river from the discharge point, 24-hour samples are collected by a continuous sampler.

Daily samples from the final access point (W2) are analyzed for uranium, alpha, and beta radioactivity. The same analyses are made on at least one sample per week from each of the river sampling points (W1 and W3). Each month, single upstream and downstream river samples collected at points W1 and W3 are analyzed for radium-226 and radium-228. Two-week composites from the waste-line final access point (W2) are analyzed for radium and 1-month composites are analyzed for thorium.

Table 2 contains information on radionuclides in water. As shown, the average concentrations of uranium, thorium, and radium added to the river was <0.001 percent of the AEC standards. The average upstream concentrations of radium-226 and radium-228 were

2.8 percent and 1.4 percent of the standard for uncontrolled areas. State criteria for gross beta and dissolved alpha radioactivity were not exceeded in the river. The calculated addition of gross dissolved alpha did average 9.8 percent of the state criteria. However, this alpha activity was due principally to uranium, for which the AEC standard is substantially higher. The more limiting state standard is intended to provide control over all alpha emitters, including radium-226, which must be kept at a concentration much lower than other less important radionuclides.

Soil monitoring

At least once each year, soil samples are collected near the 6 boundary sampling stations. Each sample consists of six cores, 2 cm in diameter and 10 cm deep. The cores are taken about 1.5 cm meters apart. These samples are analyzed for uranium to observe the possible contribution from stack effluents.

There are no standards for comparison with the results for uranium in soil listed in table 3. Although the normal value for uranium in local soil is 1–4 $\mu g/g$, there are no hazards associated with the elevated soil uranium produced by FMPC operations. External radiation from uranium is slight and the exposure contribution from these onsite concentrations would be considerably less than 1 percent of the AEC standard for people in uncontrolled areas.

Table 3. Uranium in soil, onsite locations, Feed Material Production Center, January-December 1972

Sampling point [a]	Uranium concentration			Detection level
	pCi/g (dry weight)	$\mu g/g$	95-percent confidence limit	
BS–1	0.9	2.6		
BS–2	3.9	11.8		
BS–3	14.8	44.3	±25%	0.5 $\mu g/g$
BS–4	1.5	4.4		
BS–5	2.3	6.8		
BS–6	2.5	7.4		

[a] See sampling locations shown in figure 2.

Previous coverage in *Radiation Data and Reports*:

Period	Issue
January–December 1971	September 1973

REFERENCES

(1) U.S. ATOMIC ENERGY COMMISSION. AEC manual Standards for radiation protection, Chapter 0524. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (February 4, 1969).

(2) STATE OF OHIO DEPARTMENT OF HEALTH, WATER POLLUTION CONTROL BOARD. Regulations adopted January 28, 1972; effective February 15, 1972.

(3) STATE OF OHIO DEPARTMENT OF HEALTH, WATER POLLUTION CONTROL BOARD. Resolution establishing amended criteria of streamwater quality for various uses adopted by the board on April 14, 1970.

2. Knolls Atomic Power Laboratory[3]
January–December 1972

General Electric Company
Schenectady, N.Y.

Knolls site

The Knolls site of the Knolls Atomic Power Laboratory occupies approximately 0.69 km² on the south bank of the Mohawk River, 8 km east of Schenectady. The facilities at this site include administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops, decontamination facilities; radioactive waste storage, and processing facilities; and nuclear fuel storage and assembly buildings (figure 3).

Mohawk River and municipal waters monitoring

Samples of Mohawk River water were collected at two locations 300 and 650 meters upriver and at two locations 900 and 1400 meters downriver from the Knolls site outfall during

[3] Summarized from "Knolls Atomic Power Laboratory, Annual Environmental Monitoring Report, January–December 1972."
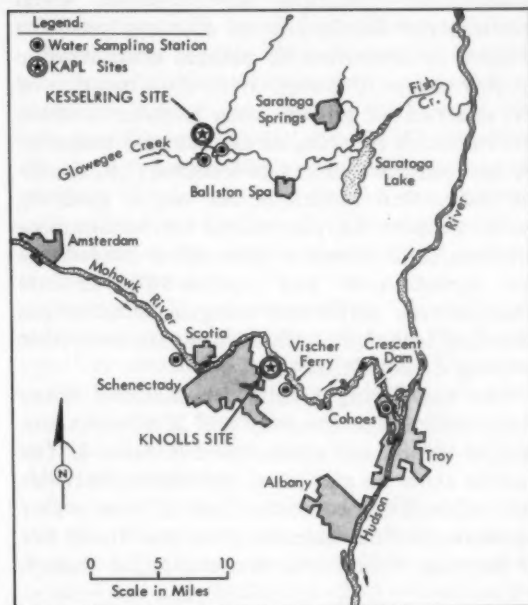
Figure 3. Environmental monitoring locations, KAPL

each of three calendar quarters; ice coverage prevented collection during the first calendar quarter. One tap water sample was collected each month from the municipal water systems of Schenectady and Miskayuna, N.Y., and from these, a separate composite sample for each system was prepared and analyzed each calendar quarter. These two water systems service the area surrounding the Knolls site.

The Mohawk River and municipal water samples were analyzed for gross alpha and beta-gamma radioactivities using alpha proportional counters and thin mica end-window geiger counters, respectively. The detection sensitivities of the analyses were approximately 1 pCi/liter and 5 pCi/liter, respectively, which correspond to the typical concentrations found in fresh water streams, principally from natural environmental radioactivity. In the event that the gross-beta concentration of a sample exceeds levels of radioactivity concentration typically found in surface water, the sample is also analyzed for strontium-90 and cesium-137; all water samples were found to contain less than the minimum detectable activity during 1972. In addition, a monthly sample of the

Schenectady municipal water system, which services the Knolls site, is also analyzed for tritium to determine its natural concentration in this source of water. With the exception of the analysis for tritium, each analysis involved the radiation counting of dry samples prepared by appropriate chemical procedures; i.e., chemical extraction technique for alpha analysis, water evaporation procedures for beta-gamma analysis, and chemical separation procedures for strontium-90 and cesium-137. Tritium analysis was performed using a sensitive gas counting technique with a minimum detectable activity of 200 pCi/liter.

The monitoring results for Mohawk River water and for Schenectady and Miskayuna municipal waters are summarized in table 4. The results show no statistical differences between the radioactivity concentrations in river water upstream and downstream from the Knolls site or between river water and municipal waters.

Using measuring techniques which detect radioactivity concentrations occurring naturally in the river water and municipal waters, no radioactivity exceeding natural background levels was detected in Mohawk River and local municipal waters. The results show that the small amount of radioactivity released in water from the Knolls site during 1972 had no significant effect on the radioactivity levels in Mohawk River and municipal waters.

Mohawk River bottom sediment

Samples of Mohawk River bottom sediment were collected during each of three calendar quarters; ice coverage prevented collection during the first calendar quarter. The samples were collected at the upriver and downriver locations from the Knolls site with a Birge-Ekman Dredge, which samples a 15 cm by 15 cm area of the top layer of sediment to an average depth of 2.5 cm. The top layer of sediment is sampled

Table 4. Monitoring results for Mohawk River water and municipal water, 1972

Location	Number of samples	Concentration (pCi/liter)					
		Beta-gamma radioactivity			Alpha radioactivity		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Mohawk River water:							
Upriver	6	ᵃ<5.2	ᵃ<4.6	ᵃ<5.1	ᵃ<0.8	ᵃ<0.6	ᵃ<0.8
Downriver	6	ᵃ<5.2	ᵃ<4.6	ᵃ<5.1	ᵃ<.8	ᵃ<.6	ᵃ<.8
Schenectady municipal water	12	ᵃ<5.3	ᵃ<4.5	ᵃ<4.9	ᵃ<.8	ᵃ<.6	ᵃ<.8
Niskayuna municipal water	12	ᵃ<5.3	ᵃ<4.5	ᵃ<4.9	ᵃ<.8	ᵃ<.6	ᵃ<.8

ᵃ Minimum detectable activity (MDA) values are expressed at the 95-percent confidence level. None of the water sample results exceeded the MDA values.

Table 5. Results of analysis of Mohawk River bottom sediment, 1972

Location	Number of samples	Radionuclide concentration (pCi/g wet weight)											
		Gross alpha ᵃ			Gross beta-gamma ᵇ			Cesium-137			Strontium-90		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Upriver	6	0.45±0.01	0.11±0.07	0.32±0.02	25±8.6	15±7.1	22±3.1	1.7±0.68	≤0.38	≤0.63±0.21			
	3										0.61±0.35	≤0.14	≤0.35±0.17
Downriver	12	1.05±.02	.17±.07	.45±.01	27±6.8	16±6.4	22±2.0	9.4±.92	≤.34	2.9±.16			
	6										.58±.21	≤.24	≤.40±.11
Opposite	3	.46±.01	.36±.01	.40±.01	29±8.1	17±7.7	22±3.8	.94±.52	≤.36	.5±.27	.43±.33	≤.21	<.32±.18

ᵃ The minimum detectable activity (MDA) was 0.02 pCi/g wet weight.
ᵇ Radioactivity was primarily natural potassium-40. The minum detectable activity (MDA) was 4.5 pCi/g wet weight.

since it should be more mobile and more accessible to marine life than deeper layers. All samples were analyzed for gross alpha activity by a chemical extraction technique, for gross beta-gamma activity by direct counting of a dried sample, and for gamma emitters by gamma spectrum analysis.

The monitoring results for Mohawk River bottom sediment for 1972 are summarized in table 5. The data indicate no statistical differences between the upriver and downriver concentrations of strontium and gross beta-gamma activity in bottom sediment and no significant increase in the average concentrations of other activities in bottom sediment downriver from the Knolls site. Although in the case of cesium-137, the maximum downriver sample concentration was several times higher than the average, this was localized and occurred near the Knolls site outfall to the river. It was attributed to operations prior to 1964. Self-imposed reductions in discharges since 1964 have curtailed further deposition of cesium-137 on the river bottom.

The average cesium-137 concentration in sediment downriver from the Knolls site corresponds to approximately 11 percent of the radioactivity concentration guide for drinking water (4). This standard is applicable to water, but for convenience and in the absence of a specific standard for sediment, is is used as a basis of comparison. This comparison, in addition to the low average levels of radioactivity in the river bottom sediment and the narrow concentration range between upriver and downriver sediment, shows that Knolls site operations are effective in protecting public health and the environment.

Air monitoring

Ventilation exhaust systems servicing radiological facilities at the Knolls site are equipped with appropriate air cleaning devices and the effluent air is continuously sampled using a filter. The resulting filter samples are collected and analyzed on a weekly basis for gross alpha and beta-gamma activities and for selected radionuclides. The detection sensitivities of the gross alpha and beta-gamma analyses were approximately 5 fCi/m³ and 30 fCi/m³, respec-

tively, which correspond to the lower concentrations currently found in environmental air.

Monitoring results show that only a small quantity of airborne radioactivity was released from the Knolls site. During 1972, only 920 μCi of particulate activity and 100 μCi of iodine-131 were released. The annual average concentrations of radioactivity in the air released well within the site boundaries were less than 1 percent of the offsite radioactivity concentration guides (4).

During 1972, approximately 1.4 curies of noble gases were also released from the Knolls site. The maximum potential dose at the boundary of the Knolls site or in the offsite environment resulting from the noble gas effluents is calculated to be less than 0.1 percent of the AEC standards (4).

The monitoring results for 1972 show that the quantity of airborne radioactivity released from the Knolls site during 1972 was too small to have had any significant effect on radioactivity levels in the environment in the vicinity of Knolls site.

Perimeter monitoring

Radiation levels at the perimeter of the Knolls site were determined by thermoluminescent dosimeters located on the site security fence and at the 15 perimeter locations. The dosimeters have a minimum detection level of approximately 3 mrem and were changed and processed monthly.

Evaluation of the monitoring data shows that the radiation levels in normally occupied areas external to the site perimeter were indistinguishable from natural background.

Estimates of potential radiation dose to the public

Although the amounts of radioactivity released from the laboratory are small and the results of environmental monitoring show that laboratory operations have had no significant effect on the environment, conservative estimates of the potential radiation dose to man have been made. Some estimates considered direct exposure, such as by drinking water from the Mohawk River, and indirect pathways, such

as consumption of food. It was shown that exposure to man from this radioactivity would be too low to measure and the maximum potential dose could only be estimated through conservative calculations based on the concentrations of radioactivity released. During 1972, the maximum radiation exposure to any member of the general public and the exposure to the population within an 80 km radius of the Knolls site were significantly less than 1 percent of the standards (4).

Kesselring site

The Kesselring site, located near West Milton, N.Y., is situated on a United States Government-owned reservation consisting of 15.8 km² located approximately 27 km north of the city of Schenectady, 14 km southwest of the city of Saratoga Springs, and 21 km northeast of the city of Amsterdam. The surrounding area is a rural, sparsely-populated region of wooded and unused farm lands through which flows the Glowegee Creek and Crook Brook, both of which flow into the Kayaderosseras Creek (figure 3). The flow eventually reaches the Hudson River, by way of Fish Creek, and thence to the Atlantic Ocean.

This site houses two operating pressurized water nuclear power plants. Additional facilities include administrative buildings, an equipment service building, a fuel service building and waste treatment operations.

The principal function of the Kesselring site is to support the U.S. Atomic Energy Commission through the operation of nuclear reactors. Regular effluent and environmental monitoring activities are conducted to assure that these operations have had no significant effect on the environment and the general public.

Water monitoring

The principal source of radioactivity considered in this report is activated corrosion and wear products from reactor plant metal surfaces in contact with reactor cooling water. Of the radionuclides which have significant half-lives (e.g., greater than 1 day), cobalt-60 is predominant in quantity, and has the most restrictive concentration guide in water established by federal regulations (4). Therefore, water releases are conservatively controlled assuming that all long-lived radioactivity is cobalt-60. Potentially radioactive water is collected and processed to reduce the concentration to the lowest practical level.

Samples of Glowegee Creek water are analyzed for radioactivity by gamma spectrometry once a month at two locations, one approximately 46 meters upstream of the point where the site enters the creek and the other approximately 460 meters downstream of the water release point (figure 3).

All Glowegee Creek water analyses results were below the minimum detectable activity concentration that may be considered valid at the 95-percent confidence level, which was 5.6 pCi/liter. The results show no statistically significant difference between the water in Glowegee Creek upstream and downstream of the site effluents.

Radioactive liquid waste is processed by filtration and deionization and monitored by analysis of samples with sensitive gamma spectrometry techniques. All water is stored in holding tanks during processing and is not released until radioactivity concentrations are below 2 percent of the AEC standards for cobalt-60 (4).

The total quantity of activity released during 1972 was less than 1.3 mCi and the total volume released to Glowegee Creek was approximately 530 Ml. Therefore, the average concentration was approximately 2.5 pCi/liter, which is less than 0.0083 percent of the AEC standard for cobalt-60 in water (4).

Sediment monitoring

Glowegee Creek bottom sediment is sampled monthly and analyzed by gamma radiation spectrometry. Sample locations are the same as those listed for Glowegee Creek water sampling. The samples are taken by scooping up the top 5 cm of sediment from the creek bottom. Each sample contains at least 500 grams of sediment.

The minimum detectable activity for cobalt-60 in sediment at the 95-percent statistical confidence level, is 0.1 pCi/g of sediment while the minimum detectable activity for the gross gamma radioactivity analysis is 0.2 pCi/g of

sediment. Table 6 presents the sediment analysis results.

The results show that there is no statistically significant difference between the sediment in Glowegee Creek upstream and downstream of the site.

Table 6. Results of Glowegee Creek sediment analysis, 1972

| Location | Number of samples | Radionuclide concentration (pCi/g wet weight) | | | | Cobalt-60 energy range [a] |
| | | Gross gamma | | | | |
		Maximum	Minimum	Average		Average
Upstream	7	13.1	8.8	11.0±3.2		1.5±0.4
Downstream	10	17.3	11.7	14.5±3.6		1.8± .4

[a] The cobalt-60 energy range includes gamma energies between 1.1 and 1.4 MeV. The values shown are the result of natural potassium-40, radium and thorium in the environment; cobalt-60 was not found in any bottom sediment sample.
Plus and minus values indicate the statistical precision at the 95-percent confidence level.

Exhaust air monitoring

Ventilation air is passed through high efficiency filters before it is released through stacks. After filtration, the air is continuously monitored by moving filter-tape air particulate monitors, charcoal filters, and/or fixed filter paper samplers. Filter papers are better than 99-percent efficient for sampling submicron and larger-sized particles. The volume sampled is known and the beta-gamma activity on the filter sample is measured, either by sensitive geiger counter techniques or by beta-gamma scintillation counters. Counting results are interpreted in terms of cobalt-60 equivalent activity concentration. Air samples are not counted for a minimum of 48 hours to allow the short-lived natural radioactivity to decay off. The only detectable gaseous radionuclide is argon-41; however, it has a half-life of less than 2 hours and does not build up in the environment.

The air monitoring data indicates no activity was released above the minimum detectable concentration at the 95-percent confidence level. Using the minimum detectable concentration,

the total activity released was less than 3 mCi during 1972. The average particulate concentration at the Kesselring site boundary, which is a minimum of 1.4 km from the nearest stack, has been estimated to be less than 0.0005 percent of the AEC standard for cobalt-60 in air (4).

Perimeter radiation monitoring

Perimeter environmental surveys are performed by placing thermoluminescence dosimeters around the site security fence. The maximum monthly average evaluated at the site perimeter shows that the annual exposure rate did not exceed the natural radiation level for this geographic location. These results indicate that the Kesselring site operations have had no significant effect on the radiation levels in the surrounding area.

Estimates of potential radiation dose to the public

Although the amounts of radioactivity released from the Kesselring site are small and the results of environmental monitoring show that site operations have had no significant effect on the environment, conservative estimates of the potential radiation dose to man have been made. Some estimates considered direct exposure, such as by drinking the water in Glowegee Creek, and indirect pathways, such as consumption of fish from Glowegee Creek. It was shown that exposure to man from this radioactivity would be too low to measure and the maximum potential dose could only be estimated through calculations based on the concentrations of radioactivity released. During 1972, the maximum radiation exposure to any member of the general public and the exposure to the population within an 80-km radius of the Kesselring site were significantly less than 1 percent of the standards (4).

Windsor site

The Windsor site, near Windsor, Conn., is situated on a United States Government-owned 4. hm² plot of land located approximately 8 km north of Hartford, Conn. The surrounding area is a rural and industrial region, through which
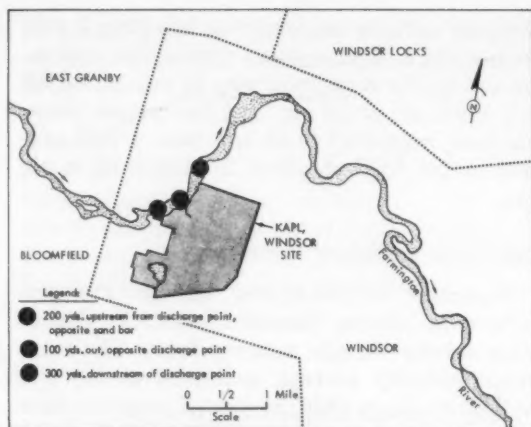
Figure 4. Environmental monitoring locations, KAPL-Windsor site (S1C Prototype)

flows the Farmington River, which empties into the Connecticut River and thence to Long Island Sound (figure 4).

This site has one pressurized water nuclear power plant. Additional facilities include an equipment service building, waste treatment operations, classrooms, and administrative offices. The primary function of the Windsor site is the training of personnel in the operation of this type of power plant. Regular effluent and environmental monitoring activities are conducted to assure that these operations have had no signfiicant effect on the environment and the general public.

Water monitoring

The principal source of radioactivity in this report is activated corrosion and wear products from reactor plant metal surfaces in contact with reactor cooling water. Of the radionuclides present which have significant half-lives (e.g., greater than 1 day), cobalt-60 is predominant in quantity and has the most restrictive concentration guide in water, established by federal regulations. Therefore, water releases are conservatively controlled assuming that all long-lived radioactivity is cobalt-60. Potentially radioactive water is controlled and processed to reduce the concentration to the lowest practical level.

Samples of Farmington River water are collected quarterly for radioactivity analysis by gamma radiation spectrometry. Figure 5 shows the three sampling locations, one approximately 180 meters upstream, another approximately 90 meters out from shore opposite the water release point, and the third approximately 270 meters downstream from it. The samples are analyzed for gross gamma activity and specifically for cobalt-60.
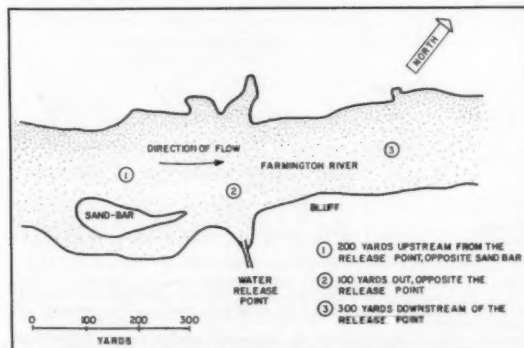
Figure 5. Farmington River sampling locations

Prior to release to the Farmington River, water from the Windsor site is collected, processed and sampled. The total activity released in the liquid waste during 1972 was less than 1 mCi. The concentration of radioactivity in water leaving the site was less than 1 percent of the AEC standard for cobalt-60 in effluent water (4).

No cobalt-60 activity was detected in the river water. The gross gamma and cobalt-60 concentrations were less than 50 pCi/liter, which was the minimum detectable concentration at the 95-percent confidence level. The results show no statistically significant difference between the radioactivity concentration in Farmington River water upstream, opposite, and downstream of the effluent point.

It is concluded that the small quantity of activity in water released from the Windsor site in 1972 has had no significant effect on the environment.

Sediment monitoring

Farmington River bottom sediment is sampled quarterly and analyzed by gamma radia-

tion spectrometry. Sample locations are the same as those shown in figure 5 for river water sampling. The samples are taken to a depth of 2.5 cm with a "clam shell" dredge. Specific gravity at standard dry weight for these samples is approximately 1.5 g/cm³.

Table 7 lists the results of Farmington River bottom sediment sample analyses for 1972. The gross gamma energy range includes all pertinent radionuclides and covers a wide gamma energy range, while the cobalt-60 energy range includes gammas from a relatively narrow range around the cobalt-60 energies. The minimum detectable activity for both the cobalt-60 and gross gamma energy analyses, at the 95-percent confidence level, was 0.1 pCi/g of sediment. No cobalt-60 was detected in any sediment sample, however, natural potassium-40 was observed in most samples.

The results show no statistically significant differences between the upstream, opposite, and downstream concentrations, indicating that the Windsor site has been successful in protecting the river environment.

Table 7. Results of Farmington River sediment analysis, 1972

Location	Number of samples	Radionuclide concentration (pCi/g)			
		Gross gamma			Cobalt-60 [a]
		Maximum	Minimum	Average	Average
Upstream	[b]3	3.1	1.4	2.3±0.1	0.5±0.1
Opposite	[b]3	2.4	2.2	2.3± .1	.4± .1
Downstream	[b]3	2.6	2.1	2.3± .1	.5± .1

[a] The cobalt-60 energy range includes gamma energies between 1.1 and 1.4 MeV. The values shown are the result of natural potassium-40, radium and thorium in the environment; cobalt-60 was not found in any bottom sediment sample.
[b] Samples not obtained during first quarter because the river was frozen. Plus and minus values indicate the statistical precision at the 95-percent confidence level.

Exhaust air monitoring

Ventilation air is directed through high efficiency filters before it is released through stacks. The main stack is monitored by a fixed filter sampling system which is changed weekly and analyzed by sensitive radiation counting equipment calibrated to a cobalt-60 standard. The chemistry laboratory is monitored continuously by a moving filter air particulate detector with adjustable alarm and chart recorder. The only detectable gaseous radionuclide is argon-41; however, it has a half-life of less than 2 hours and does not build up in the environment.

The total particulate activity released from the Windsor site during 1972 was less than 1 mCi. The average particulate concentration at the Windsor site boundary has been estimated to be less than 0.0002 percent of the AEC standard for cobalt-60 in air (4).

Perimeter radiation monitoring

The site perimeter fence is monitored with film badges at eight locations. This film is changed and evaluated monthly. The annual average exposure rate did not exceed the natural radiation level for this geographic location. It is concluded that Windsor site operations have had no significant effect on the natural background radition levels of the surrounding area.

Estimates of potential radiation dose to the public

Although the amounts of radioactivity released from the Windsor site are small and the results of environmental monitoring show that site operations have had no significant effect on the environment, conservative estimates of the potential radiation dose to man have been made. Some estimates considered direct exposure, such as by drinking the water in the Farmington River and indirect pathways, such as consumption of food. It was shown that exposure to man from this radioactivity would be too low to measure and the maximum potential dose could only be estimated through conservative calculations based on the concentrations of radioactivity released. During 1972, the maximum radiation exposure to any member of the general public and the exposure to the population within an 80 km radius of the Windsor site were significantly less than 1 percent of the standards (4).

REFERENCE

(4) U.S. ATOMIC ENERGY COMMISSION. U.S. Atomic Energy Commission Manual Chapter 0524 (October 8, 1968).

Nuclear Power Reactors in the United States
June 30, 1974

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of *Radiation Data and Reports*.
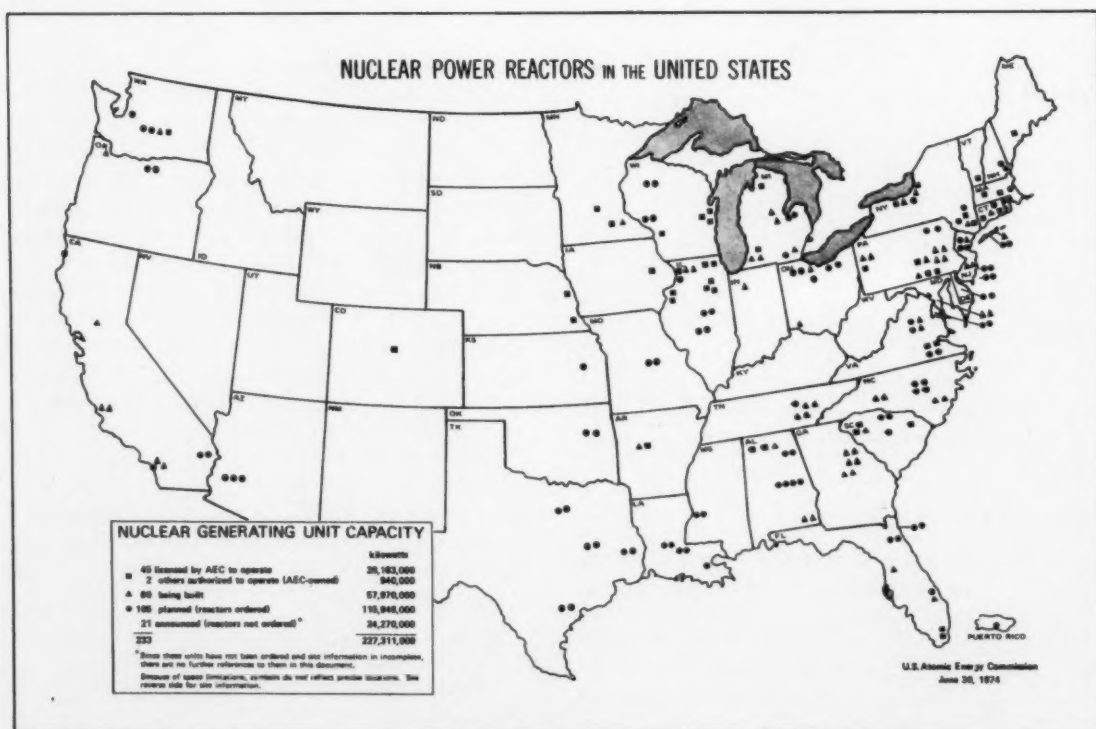

Figure 1.   Nuclear power reactors in the United States, June 30, 1974

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1974
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1974
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
Chilton County	Central Alabama Nuclear Plant: Unit 1	1,200,000	Alabama Power Co.	1982
Chilton County	Central Alabama Nuclear Plant: Unit 2	1,200,000	Alabama Power Co.	1983
Elmore County	Central Alabama Nuclear Plant: Unit 3	1,200,000	Alabama Power Co.	1984
Elmore County	Central Alabama Nuclear Plant: Unit 4	1,200,000	Alabama Power Co.	1985
Scottsboro	Bellefonte Nuclear Plant: Unit 1	1,213,000	Tennessee Valley Authority	1979
Scottsboro	Bellefonte Nuclear Plant: Unit 2	1,213,000	Tennessee Valley Authority	1980
ARIZONA				
Wintersburg	Palo Verde Nuclear Generation Station: Unit 1	1,270,000	Arizona Public Service	1981
Wintersburg	Palo Verde Nuclear Generating Station: Unit 2	1,270,000	Arizona Public Service	1982
Wintersburg	Palo Verde Nuclear Generating Station: Unit 3	1,270,000	Arizona Public Service	1984
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	850,000	Arkansas Power & Light Co.	1974
Russellville	Arkansas Nuclear One: Unit 2	912,000	Arkansas Power & Light Co.	1976
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	65,000	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1968
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1979
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1980
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,084,000	Pacific Gas and Electric Co.	1975
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,106,000	Pacific Gas and Electric Co.	1976
Clay Station	Rancho Seco Nuclear Generating Station	804,000	Sacramento Municipal Utility District	1974
°	–	1,128,000	Pacific Gas & Electric Co.	1981
°	–	1,128,000	Pacific Gas & Electric Co.	1982
Vidal	Vidal Generating Station: Unit 1	770,000	Southern California Edison Co.	1981
Vidal	Vidal Generation Station: Unit 2	770,000	Southern California Edison Co.	1982
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1974
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1968
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1971
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
Waterford	Millstone Nuclear Power Station: Unit 3	1,156,000	Northeast Utilities	1979
DELAWARE				
Summit	Summit Power Station: Unit 1	770,000	Delmarva Power & Light Co.	1980
Summit	Summit Power Station: Unit 2	770,000	Delmarva Power & Light Co.	1982
FLORIDA				
Florida City	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1972
Florida City	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1973
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1974
Ft. Pierce	St. Lucie Plant: Unit 1	801,000	Florida Power & Light Co.	1975
Ft. Pierce	St. Lucie Plant: Unit 2	801,000	Florida Power & Light Co.	1979
°	–	1,300,000	Florida Power Corp.	1983
°	–	1,300,000	Florida Power Corp.	1986
Jacksonville	Offshore Unit 1	1,150,000	Jacksonville Electric Authority	1982
Jacksonville	Offshore Unit 2	1,150,000	Jacksonville Electric Authority	1984
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1974
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	795,000	Georgia Power Co.	1978
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 1	1,113,000	Georgia Power Co.	1980
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 2	1,113,000	Georgia Power Co.	1981
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 3	1,113,000	Georgia Power Co.	1982
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 4	1,113,000	Georgia Power Co.	1983
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1973
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1974
Cordova	Quad-Cities Station: Unit 1	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Cordova	Quad-Cities Station: Unit 2	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle County Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1978
Seneca	LaSalle County Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1979
Bryon	Byron Station: Unit 1	1,120,000	Comm. Edison Co.	1980
Bryon	Byron Station: Unit 2	1,120,000	Comm. Edison Co.	1981
Braidwood	Braidwood: Unit 1	1,120,000	Comm. Edison Co.	1980
Braidwood	Braidwood: Unit 2	1,120,000	Comm. Edison Co.	1981
Clinton	Clinton Nuclear Power Plant: Unit 1	955,000	Illinois Power Co.	1980
Clinton	Clinton Nuclear Power Plant: Unit 2	955,000	Illinois Power Co.	1982
INDIANA				
Porter County	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1979
IOWA				
Palo	Duane Arnold Energy Center: Unit 1	540,000	Iowa Electric Light and Power Co.	1974
KANSAS				
Burlington	Wolf Creek Generation Station: Unit 1	1,150,000	Kansas Gas & Electric—Kansas City P & L	1981
LOUISIANA				
Taft	Waterford Generating Station	1,113,000	Louisiana Power & Light Co.	1977
St. Francisville	River Bend Station: Unit 1	934,000	Gulf States Utilities Co.	1980
St. Francisville	River Bend Station: Unit 2	934,000	Gulf States Utilities Co.	1981
Alliance	St. Rosalie Generating Station: Unit 1	1,200,000	Louisiana Power & Light Co.	1982
Alliance	St. Rosalie Generating Station: Unit 2	1,200,000	Louisiana Power & Light Co.	1984

Figure 1.   Nuclear power reactors in the United States, June 30, 1974—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1974
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1975
Nanjemoy	Douglas Point Project: Unit 1	1,178,000	Potomac Electric Power Co.	1980
Nanjemoy	Douglas Point Project: Unit 2	1,178,000	Potomac Electric Power Co.	1981
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station: Unit 1	664,000	Boston Edison Co.	1972
Plymouth	Pilgrim Station: Unit 2	1,180,000	Boston Edison Co.	1980
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	75,000	Consumers Power Co.	1965
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,093,000	Detroit Edison Co.	1976
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 3	1,171,000	Detroit Edison Co.	1981
Bridgman	Donald C. Cook Plant: Unit 1	1,060,000	Indiana & Michigan Electric Co.	1974
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1976
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1980
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1979
St. Clair County	Greenwood: Unit 2	1,200,000	Detroit Edison Co.	1980
St. Clair County	Greenwood: Unit 3	1,200,000	Detroit Edison Co.	1981
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1973
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
MISSOURI				
Fulton	Callaway Plant: Unit 1	1,150,000	Union Electric Co.	1981
Fulton	Callaway Plant: Unit 2	1,150,000	Union Electric Co.	1983
MISSISSIPPI				
Port Gibson	Grand Gulf Nuclear Station: Unit 1	1,250,000	Mississippi Power & Light Co.	1979
Port Gibson	Grand Gulf Nuclear Station: Unit 2	1,250,000	Mississippi Power & Light Co.	1981
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1974
NEW HAMPSHIRE				
Seabrook	Seabrook Nuclear Station: Unit 1	1,200,000	Public Service of N.H.	1979
Seabrook	Seabrook Nuclear Station: Unit 2	1,200,000	Public Service of N.H.	1981
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	640,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,070,000	Jersey Central Power & Light Co.	1979
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N.J.	1975
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N.J.	1976
Salem	Hope Creek Generating Station: Unit 1	1,067,000	Public Service Electric and Gas, N.J.	1981
Salem	Hope Creek Generating Station: Unit 2	1,067,000	Public Service Electric and Gas, N.J.	1982
Little Egg Inlet	Atlantic Generating Station: Unit 1	1,150,000	Public Service Electric and Gas, N.J.	1980
Little Egg Inlet	Atlantic Generating Station: Unit 2	1,150,000	Public Service Electric and Gas, N.J.	1981
°	–	1,150,000	Public Service Electric and Gas, N.J.	1983
°	–	1,150,000	Public Service Electric and Gas, N.J.	1984
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1962
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1973
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1974
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1969
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,080,000	Niagara Mohawk Power Co.	1978
Ontario	R. E. Ginna Nuclear Power Plant: Unit 1	490,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
Jamesport	Jamesport 1 –	1,150,000	Long Island Lighting Co.	1981
Jamesport	Jamesport 2 –	1,150,000	Long Island Lighting Co.	1983
Oswego	Sterling Nuclear: Unit 1	1,150,000	Rochester Gas & Electric Co.	1982
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1976
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1981
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1982
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1983
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1984
Davie County	Perkins Nuclear Station: Unit 1	1,280,000	Duke Power Co.	1981
Davie County	Perkins Nuclear Station: Unit 2	1,280,000	Duke Power Co.	1982
Davie County	Perkins Nuclear Station: Unit 3	1,280,000	Duke Power Co.	1982
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 1	906,000	Toledo Edison-Cleveland El. Illum. Co.	1976
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 2	906,000	Toledo Edison-Cleveland El. Illum. Co.	1981
Oak Harbor	Davis-Besse Nuclear Power Station: Unit 3	906,000	Toledo Edison-Cleveland El. Illum. Co.	1983
Perry	Perry Nuclear Power Plant: Unit 1	1,205,000	Cleveland Electric Illuminating Co.	1979
Perry	Perry Nuclear Power Plant: Unit 2	1,205,000	Cleveland Electric Illuminating Co.	1980
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1977
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 2	1,170,000	Cincinnati Gas & Electric Co.	1982

Figure 1.   Nuclear power reactors in the United States, June 30, 1974—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
OKLAHOMA				
Inola	Black Fox Nuclear Station: Unit 1	950,000	Public Service of Oklahoma	1982
Inola	Black Fox Nuclear Station: Unit 2	950,000	Public Service of Oklahoma	1984
OREGON				
Prescott	Trojan Nuclear Plant: Unit 1	1,130,000	Portland General Electric Co.	1975
•	—	1,260,000	Portland General Electric Co.	1981
•	—	1,260,000	Portland General Electric Co.	1983
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1974
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1979
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1980
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	852,000	Duquesne Light Co.-Ohio Edison Co.	1975
Shippingport	Beaver Valley Power Station: Unit 2	852,000	Duquesne Light Co.-Ohio Edison Co.	1979
Goldsboro	Three Mile Island Nuclear Station: Unit 1	819,000	Metropolitan Edison Co.	1974
Goldsboro	Three Mile Island Nuclear Station: Unit 2	905,000	Jersey Central Power & Light Co.	1976
Berwick	Susquehanna Steam Electric Station: Unit 1	1,050,000	Pennsylvania Power and Light	1979
Berwick	Susquehanna Steam Electric Station: Unit 2	1,050,000	Pennsylvania Power and Light	1981
Fuller	Fulton Generating Station: Unit 1	1,140,000	Philadelphia Electric Co.	1981
Fuller	Fulton Generating Station: Unit 2	1,140,000	Philadelphia Electric Co.	1983
SOUTH CAROLINA				
Hartsville	H. B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1974
Broad River	Virgil C. Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1978
Lake Wylie	Catawba Nuclear Station: Unit 1	1,153,000	Duke Power Co.	1979
Lake Wylie	Catawba Nuclear Station: Unit 2	1,153,000	Duke Power Co.	1980
Cherokee County	Cherokee Nuclear Station: Unit 1	1,280,000	Duke Power Co.	1982
Cherokee County	Cherokee Nuclear Station: Unit 2	1,280,000	Duke Power Co.	1983
Cherokee County	Cherokee Nuclear Station: Unit 3	1,280,000	Duke Power Co.	1984
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,140,000	Tennessee Valley Authority	1975
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,140,000	Tennessee Valley Authority	1976
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1978
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1978
Oak Ridge	Clinch River Breeder Reactor Plant	350,000	U.S. Government	1980
TEXAS				
Glen Rose	Commanche Peak Steam Electric Station: Unit 1	1,150,000	Texas Utilities Services Inc.	1980
Glen Rose	Commanche Peak Steam Electric Station: Unit 2	1,150,000	Texas Utilities Services Inc.	1982
Jasper	Blue Hills: Unit 1	918,000	Gulf States Utilities	1982
Jasper	Blue Hills: Unit 2	918,000	Gulf States Utilities	1982
Wallis	Allens Creek: Unit 1	1,150,000	Houston Lighting & Power Co.	1980
Wallis	Allens Creek: Unit 2	1,150,000	Houston Lighting & Power Co.	1982
Matagorda County	South Texas Project	1,250,000	Central Power & Light Co.	1980
Matagorda County	South Texas Project	1,250,000	Central Power & Light Co.	1982
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1972
VIRGINIA				
Gravel Nec.:	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1973
Mineral	North Anna Power Station: Unit 1	898,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 2	898,000	Virginia Electric & Power Co.	1976
Mineral	North Anna Power Station: Unit 3	907,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	907,000	Virginia Electric & Power Co.	1978
Gravel Neck	Surry Power Station: Unit 3	859,000	Virginia Electric & Power Company	1980
Gravel Neck	Surry Power Station: Unit 4	859,300	Virginia Electric & Power Company	1981
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	850,000	Atomic Energy Commission	1966
Richland	WPPSS No. 1	1,206,000	Washington Public Power Supply System	1980
Richland	WPPSS No. 2	1,103,000	Washington Public Power Supply System	1977
Satsop	WPPSS No. 3	1,242,000	Washington Public Power Supply System	1981
Sedro Woolley	Skagit Nuclear Project	1,200,000	Puget Sound Power & Light	1982
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	50,000	Dairyland Power Cooperative	1971
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1970
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Michigan Power Co.	1973
Ft. Atkinson	Koshkonong Nuclear Plant: Unit 1	900,000	Wisconsin Electric Power Co.	1981
Ft. Atkinson	Koshkonong Nuclear Plant: Unit 2	900,000	Wisconsin Electric Power Co.	1982
Durand	Tyrone Energy Park: Unit 1	1,150,000	Northern States Power Co.	1982
Durand	Tyrone Energy Park: Unit 2	1,150,000	Northern States Power Co.	1983
PUERTO RICO				
Puerto De Jdbas	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1979
* Site not selected.				
•	—	1,205,000	Tennessee Valley Authority	1980
•	—	1,205,000	Tennessee Valley Authority	1981
•	—	1,205,000	Tennessee Valley Authority	1980
•	—	1,205,000	Tennessee Valley Authority	1981
•	—	1,200,000	New England Electric System	1982
•	—	1,200,000	New England Electric System	1982

Figure 1. Nuclear power reactors in the United States, June 30, 1974—continued

Reported Nuclear Detonations, August 1974

(Includes seismic signals presumably from foreign nuclear detonations)

A nuclear test with a yield of less than 20 kilotons was conducted August 14, 1974, by the Atomic Energy Commission at its Nevada Test Site.

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States. The signals originated at 11:00 a.m., e.d.t., August 14, 1974, from the Tazovskiy Peninsula area in Northwestern Siberia and were equivalent to those of an underground nuclear explosion in the yield range of 20 to 200 kilotons.

Seismic signals from a large Soviet underground nuclear test were recorded by the United States. The signals originated at approximately 6 a.m., e.d.t., August 29, 1974, in the Novaya Zemlya Island area in the Arctic Ocean and indicated a yield of 1 to 3 megatons.

A nuclear test in the low-intermediate yield range (20 to 200 kilotons TNT equivalent) was conducted by the Atomic Energy Commission at its Nevada Test Site on August 30, 1974.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

HF SPECTRAL ACTIVITY IN THE WASHINGTON, D.C. AREA. *Richard A .Tell, John C. Nelson, and Norbert N. Hankin. Radiation Data and Reports, Vol. 15*, September 1974, pp. 549–558.

The results of preliminary study on the spectral activity of the high frequency band from 0 to 100 MHz with emphasis on the 2–22 MHz band segment are presented. In the 0–2 MHz band segment, which includes the AM standard broadcast region, the highest mean number of signals recorded in any one hour was approximately 14.3 that occurred at 1800 e.d.t., the minimum mean number of signals observed was 8.2 occurring at 0200 e.d.t., and the maximum integral relative power density occurred at 1800 e.d.t.

In the 2–22 MHz band, the peak band activity and peak integral spectral power density both occur between 1800 and 2400 e.d.t. The maximum integral power density is about 20 dB greater during this time period than at other times.

For the overall band of 0–100 MHz, the highest activity appears to occur from about 0900 to 1800 e.d.t. There is a lull in activity that occurs in the early morning hours (0200 to 0600 e.d.t.). The inactivity of nonbroadcast sources is generally correlated with the overall band activity. Measurements show that signals of nonbroadcast origin are significantly lower in amplitude than signals in the broadcast bands.

KEYWORDS: Microwave, radiofrequency, Washington, D.C.

AN EVALUATION PROCEDURE FOR A NUCLEAR MEDICAL DEPARTMENT. *David Metz, Stanley J. Malsky, Charles J. Blatt, David B. Hayt, Arthur Frie, Peter A. Betar, John Macca, and Donald Simon. Radiation Data and Reports. Vol. 15*, September 1974, pp. 559–566.

This study presents administrative, health physics, educational, instrumentation and space requirements for departments of nuclear medicine. The data were recorded from answers to a questionnaire and personal interviews with personnel in hospitals with varying bed capacities. Finally, a visual inspection was made of each department by personnel conducting the interview.

KEYWORDS: Hospital, medical procedure, New York, radioisotopes.

SIGNIFICANCE OF STABLE IODINE-127 IN MILK. *William J. Kelleher* and *Harvey R. Prins. Radiation Data and Reports, Vol. 15*, September 1974, pp. 567–573.

The unexpected high concentrations of stable iodine in milk found when studying the specific activity concept for iodine-129 around a nuclear fuels reprocessing plant led to an evaluation of the use of iodine-129 to iodine ratio in milk samples to calculate population doses. In order to use specific activity to calculate thyroid dose, it will be necessary to establish values for the concentration of iodine in thyroids. If a constant concentration of iodine in the thyroid is assumed and there is a high enough concentration of iodine in the milk to be able to assume that milk is the only source of iodine in the thyroid, a relationship between thyroid dose and the iodine-129 to iodine or iodine-131 to iodine ratios can be developed. The use of specific activity in milk to determine dose will have the greatest application in evaluating the man-rem dose from the discharge of iodine-129 from fuel reprocessing plants.

KEYWORDS: Doses, iodine-127, iodine-131, milk, population, specific activity, thyroid.

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